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16. Abstract

This is the fifteenth issue of NASA's USSR Space Life Sciences Digest. It contains abstracts of 59 papers published in Russian language periodicals or presented at conferences and of two new Soviet monographs. Selected abstracts are illustrated with figures and tables from the original. An additional feature is the review of a conference devoted to the physiology of extreme states. The abstracts included in this issue have been identified as relevant to 29 areas of space biology and medicine. These areas are adaptation, biological rhythms, biospherics, body fluids, botany, cardiovascular and respiratory systems, endocrinology, enzymology, equipment and instrumentation, exobiology, genetics, habitability and environmental effects, human performance, immunology, life support systems, mathematical modeling, metabolism, microbiology, musculoskeletal system, neurophysiology, nutrition, operational medicine, perception, personnel selection, psychology, radiobiology, reproductive biology, and space biology and medicine.

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* Topics marked with * have no entries of their own, but refer readers to relevant abstracts included in other topic areas.

USSR Space Life Sciences Digest: Number 10 Reader Feedback Form

To our readers: We are working in a large number of highly technical, specialized areas for which adequate Russian-English glossaries have yet to be compiled. We ask your help in improving the accuracy and specificity or our English terminology. Please fill out the form below whenever you encounter an incomprehensible, incongruous, awkward or otherwise inappropriate term. While we solicit all suggestions for improved renderings, the statement that a term is inappropriate provides us with useful information, even when no better alternative can be suggested. A copy of this form will appear in all future issues of the Digest. Thank you for your help.

Abstract #	Incorrect or contextually inappropriate word or phrase:	Suggested rendering: ("??" is an acceptable entry)

PLEASE RETURN TO: Dr. Lydia Hooke
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FROM THE EDITORS

This is the fifteenth issue of the USSR Space Life Sciences Digest. Approximately one half of the abstracts in this issue are translated from a book of abstracts of papers delivered at a conference on Space Biology and Aerospace Medicine held in the Soviet Union in 1986. Because of the availability of this source, 34 of the abstracts in this issue present, or at least discuss, space flight data from Salyut, and Cosmos biosatellite flights. We would like to remind readers that at present all we have access to are abstracts and thus are unable to provide any additional information concerning the papers covered.

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ADAPTATION

(See also: Biological Rhythms: M119; Cardiovascular and Respiratory Systems: P629; P678; Musculoskeletal System: P647; Psychology: P648)

PAPER:

P683(15/88)* Polyakov BI.
Discrete adaptation to [conditions of] sensory conflict.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 82-82; 1987.
[50 references; 11 in English]

Adaptation; Neurophysiology, Space Motion Sickness, Electric Sleep
Humans, Cosmonauts, Theoretical Article
Perception, Sensory Conflict

Abstract: In this paper, the author argues that the best program for facilitation of adaptation in general and adaptation to sensory conflict leading to space motion sickness in particular is to interrupt adaptation periods with respite from the conditions requiring adaptation. The most desirable way of doing this, in his view, is by electrical induction of sleep or other techniques of controlled sleep, or by central electroanalgesia.

BIOLOGICAL RHYTHMS

PAPER:

P661(15/88)* Klimovitskiy VYa, Alpatov AM (USSR), Sulzman FM, Fuller CA, Moore-Ede M (USA).
Circadian rhythms and temperature hemostasis in monkeys inflight on Cosmos-1514 biosatellite.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 14-18.
[22 references; 11 in English]

Biological Rhythms, Circadian Rhythms, Skin and Body Temperature
Primates, Macaca mulatta
Space Flight, Short-term, Cosmos-1514

Abstract: Studies were performed on two monkeys (Macaca mulatta), Abrek and Bion, participating in a 5-day space flight on board Cosmos-1514. A control group was identically treated in all respects except for flight. One experimental subject had previously been studied in a biosatellite mock-up 1 month preflight. Before the experiment, animals were maintained in cages or primate chairs. Animals had been regularly acclimated to conditions of restraint, feeding, and illumination. During the experiment animals in both groups were strapped in Bios capsules with "daylight" illumination for 16 hours per day. Air temperature in the capsules was maintained at 23-25°C. The following schedule was enforced: 0:00 to 8:00 - nocturnal illumination, 8:00-10:00 and 16:00-18:00 - "operator activity" with juice reinforcement, 10:00-12:00 and 18:00-20:00 feeding. Circadian rhythms were studied by measuring body and skin temperature and motor activity. Axillary body temperature was measured with an implanted sensor and skin temperature by a sensor glued to a shaved area on the right leg. The activity sensor was attached to the chest strap holding the animal in the chair. Values for all three parameters were recorded every 16 minutes.

In flight, body temperature of both subjects continued to show marked circadian rhythms with maximal temperature during the day and minimal at night. Mean diurnal body temperature decreased gradually throughout the flight, with the nocturnal minimum dropping the most. During the flight skin temperature changed from 25° to 35°. Launch was associated with a short-term increase in skin temperature. During exposure to weightlessness, skin temperature remained very low, exceeding environmental temperature by only 2-4°C. In Abrek diurnal rhythm of skin temperature was maintained, while in Bios rhythm reappeared only on day 5 of flight. Diurnal rhythm in motor activity was maintained in both animals, with Abrek being much more active in general. Analysis of periodograms suggested maintenance of normal diurnal rhythms in both animals, with a only slight discrepancy (25-hour cycle in Bios), however, the study was too limited in duration to produce reliable data on periodicity.

The authors argue that the data does not distinguish between true circadian rhythms and rhythms induced by schedules of illumination and activity. Hypothermia observed in space flight may be attributed to decreased heat generation from muscles, particularly, slow-twitch muscles. The authors

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hypothesize that under exposure to weightlessness, body temperature is controlled less stringently and is more dependent on environmental temperature.

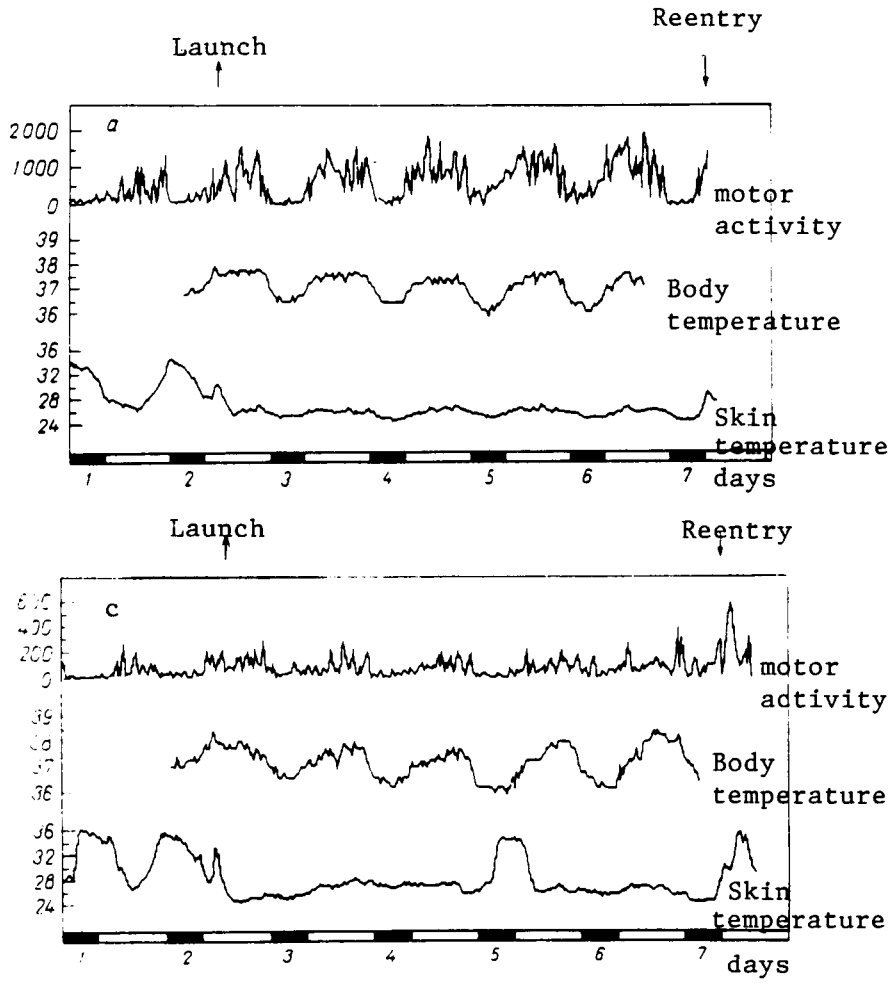

Figure 1: Circadian rhythms in motor activity, body temperature, and skin temperature in Abrek (a) and Bion (b)

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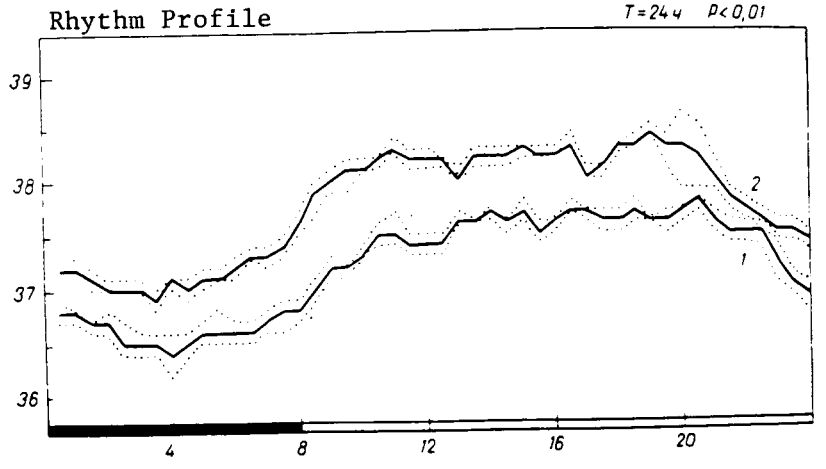

Figure 2: Averaged rhythm profile with standard deviations.
1 - Abrek in flight; 2 - Abrek in ground study.

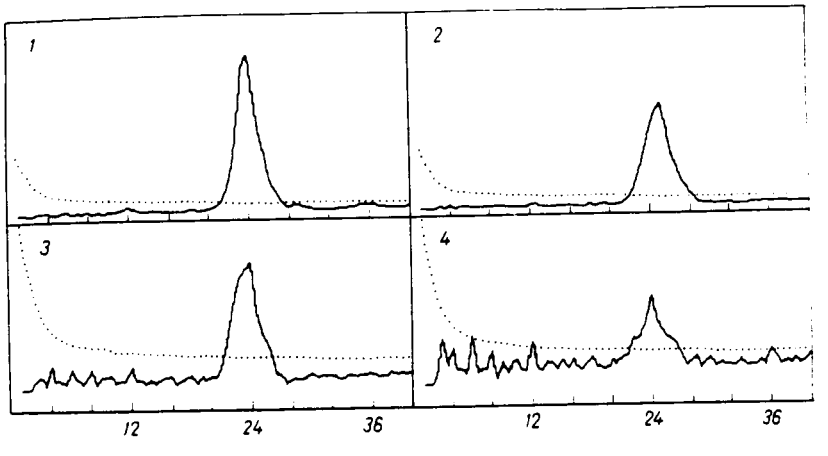

Figure 3: Periodogram analysis: spectra or rhythms in monkeys inflight.
1 and 3 - respectively, body temperature and motor activity in Abrek.
2 and 4 - the same for Bios. Dotted line - $p < 0.01$ significance level.

MONOGRAPH:

M119(15/88) Emel'yanov IP.
Struktura Biologicheskikh Ritmov Cheloveka v Protsesse Adaptatsii Statisticheskiy Analiz i Modelirovaniye [**Structure of Human Biological Rhythms in the Process of Adaptation. Statistical Analysis and Modeling**]
Novosibirsk: Nauka; 1986.
[180 pages]
Affiliation: USSR Academy of Sciences (Siberian Division), Yakustsk Affiliate of the Division of Applied Math and Computer Technology (book).

Key Words: Biological Rhythms, Adaptation, Far North, Mathematical Modeling

Annotation: This monograph is devoted to current theory and practice in the study of biological rhythms, and development of mathematical methods for analyzing them. A new research area in the physiology of circadian rhythms and human adaptation to climatogeographic and other environmental factors is discussed. This research has led to development of criteria indicative of human adaptive potential and functional state under experimental simulations of conditions in the far north. Three algorithms and two functional hardware systems for automating scientific experiments [in this area] are offered. This book is intended for scientists and specialists in the area of bionics, biological cybernetics, physiology, and applied mathematics.

CONTENTS

(Numbers in parentheses refer to page numbers in original.

BIOSPHERICS: See Exobiology: P652; Space Biology and Medicine: M118)

BODY FLUIDS

PAPERS:

P662(15/88)* Zhidkov VV, Abrosimov SV, Endeka DK, Borisov GI, Lobachik VI, Korol'kov VV, Il'in YeA.
The effects of space flight factors on hydration homeostasis in monkeys.
Kosmicheskaya Biologiya i Aviaskosmicheskaya Meditsina.
21(5): 19-22; 1987.
[6 references; 3 in English]

Body Fluids, Extracellular, Intracellular, Interstitial Fluid, Blood
Primates, Monkeys
Space Flight, Short-term, Cosmos-1667

Abstract: The goal of this study was investigation of the effects of 7-day exposure to space flight factors on hydration homeostasis of 2 male monkeys (Verny and Gordy). Nuclear physics (i.e., radioactive tracing) methods were used. Measurements of the total fluid volume of the body were obtained using a single dose (0.074 MBq) of $^{3}H_2O$ and of vascular fluid using ^{131}I-albumen in a single dose of 0.02 MBq. Content of extracellular fluid was determined using a single dose (0.05 g) of stable bromine followed by fluorescent X-rays. Volumes of intracellular and interstitial fluid were calculated using traditional methods. The monkeys were examined in a baseline period, at reentry (within 1.5 hours), and during month 4 postflight.

Baseline studies showed that hydration homeostasis and its infrastructure were within the norms for both flight animals, however, levels were below those of control subjects. Postflight studies showed that Verny had lost 1% lean body weight, while Gordy had lost 2% lean body weight but increased in fat. Verny displayed only an insignificant decrease in absolute and relative total body fluid, while intracellular fluid remained at baseline value. Gordy's absolute and especialy relative total body fluid decreased, as did his intracellular fluid. Both monkeys showed decreases in relative and absolute extracellular fluid. Interstitial fluid decreased by 6.3 and 2.9% (corrected for body weight) in Verny and Gordy, respectively; while blood plasma decreased by 9.4% and 6.8%. During the 4-month readaptation period, the intracellular proportion of body fluid tended to increase, while extracellular proportion showed a slight decrease; ratio of plasma to interstitial fluid decreased. These changes are characteristic of growing animals. Postflight, Gordy showed a slight decrease in extracellular proportion of body fluid and an increase in intracellular proportion, while Verny displayed no changes. [Note that the reverse is shown by the table.] No changes were noted in relationship between interstitial fluid and plasma. Changes observed were less pronounced than those seen in the monkey Abrek after a 5-day flight on Cosmos-1514 (See P661 above).

Table 1: State of body fluids in monkeys Gordy and Verny before and after space flight

Parameter	Units	Verny			Gordy		
		Pre-flight	Post-flight	Recovery	Pre-flight	Post-flight	Recovery
Total body fluid	ml	2262	2209	2510	2240	2210	2440
(TBF)	ml/kg	560	548	564	541	515	542
Extracellular fluid volume	ml	934	890	1004	915	905	987
(EFV)	ml/kg	231	221	226	221	211	222
Intracellular fluid volume	ml	1328	1320	1506	1325	1305	1443
(IFV)	ml/kg	329	327	338	319	304	321
Circulating plasma volume	ml	192	174	190	205	191	202
(CPV)	ml/kg	47	43	43	49	44	45
Interstitial fluid volume	ml	767	716	814	710	714	785
(ISF)	ml/kg	190	178	183	171	166	177

Table 2: Ratios (in %) of the fluid fractions in the bodies of monkeys before and after a 7-day flight

Monkey	Period	IFV/TBF	EFV/TBF	EFV/IFV	ISF/TBF	CPV/EFV	CPV/ISF
Verny	Preflight	58.7	41.3	70.3	82.1	20.5	25.0
	Postflight	59.8	40.3	67.4	80.4	19.5	24.3
	Recovery	60.0	40.0	66.6	81.1	18.9	23.3
Gordy	Preflight	59.0	40.9	69.1	77.5	22.4	28.8
	Postflight	59.0	40.9	69.2	78.8	21.1	26.7
	Recovery	59.2	40.4	68.3	79.6	21.1	25.7

P675(15/88)* Lobachik VI, Korsunskiy VN, Popov VI, Abrosimov SV, Zhidkov VV, Andretsov VA.
Isotope methods for assessing blood redistribution in the body.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 65-67; 1987.
[8 references; 1 in English]

Body Fluids, Fluid Redistribution
Equipment and Instrumentation, Radiotracer System
Weightlessness Simulations, Hypokinesia with Head-Down Tilt, Immersion

Abstract: To assess the adequacy of ground-based models of space flight, it is important to know how much fluid (blood) redistribution they induce. Most existing methods give only a qualitative idea of the extent of this response. The authors propose a method based on radiotracers. The method selected had to meet the following criteria: provide a stringently quantitative picture of the process of blood redistribution and reliably record its distribution throughout the body and in specific regions; be usable in all hypokinesia and immersion experimental paradigms; be compatible with traditional tests used in space physiology, such as tilt tests, LBNP, bicycle ergometry and others; and be capable of inducing fluid shifts. The radioactive label selected had to be an isotope which when injected into the blood would distribute itself homogeneously throughout the ciculatory system. To best reflect the whole range of effects, two isotopes should be used, one carried by the plasma, and one by erythrocyte cells. Neither isotope could be preferentially attracted to any one organ or tissue; and each had to: emit gamma-rays; be bound strongly with the carrier, remain in the blood stream for a relatively long period; not enter into metabolic processes; have a short half-life; and cause minimal biological effects. Radiation from the two isotopes had to be readily discriminable. The isotopes selected on the basis of these criteria were ^{113m}In-citrate (for plasma) and ^{99m}Tc-pyrophosphate. Existing radiometric systems were not suitable for the purpose of this study. The authors designed a multisensor system to simultaneously record activity in the entire body, as well as individual regions (head, chest, stomach, and lower limbs). Scintillating sensors were located under each body region (with two under the legs). Lead screens were placed at the border between regions, virtually eliminating registration of activity from neighboring regions. Optimal geometry for locating sensors and screens was developed theoretically and through experiments on phantoms. This device has given good results in a number of weightlessness experiments.

Figure: Radiometric device.

PAPERS:

P643(15/88) Zhvalikovskaya VP.
Use of higher plants for genetic monitoring of space flights.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 271-273.

Genetics, Genetic Monitoring, Chromosome Aberrations
Botany, Higher Plants
Space Flight, Radiobiology, Galactic Radiation, Temperature

Abstract: Higher plants are increasingly being used for continuous monitoring of genetic dangers attibutable to the environment in the most diverse ecological systems and ecological niches: in the atmosphere, water, cities, and agrarian regions. Higher plants possess properties which make them suitable for for use in environmental monitoring in manned spacecraft. The complexity of the plant genome is comparable to the complexity of the mammalian genome. Tests for mutability may be conducted using generative as well as somatic cells. Exposure of plants may have unlimited duration. Plants are the quintessential natural subjects, since they comprise the predominant portion of the biomass of any ecological system.

Many experiments with dry seeds on spacecraft have shown a small but statistically significant increase in the frequency of chromosomal aberrations compared to transport and laboratory control conditions. Destruction was attributable to changes in the frequency of chromosome restructuring, as distinguished from a spontaneous process of mutation. The most common aberration was chromatide restructuring. The seeds of various plant species have frequently showed changes in germination ability and rate.

Interpretation of the results obtained in experiments with higher plants has been very difficult. The laws of radiobiology have been the starting point for the quantitative evaluation of effects obtained during genetic monitoring of the environment. Nonetheless, attempts to explain the occurrence of genetic changes in plants, and in other subjects exposed to cosmic ionizing radiation, have been unsuccessful primarily because of the lack of correlation between effect magnitude and flight duration. In addition, the total dose absorbed in flights of manmade satellites is low. For example, during Spacelab flights the calculated absorbed dose of ionizing radiation was approximately 30 mGy per year. Even under laboratory conditions, with other variables strictly controlled, it is difficult to detect biological effects of radiation doses so small.

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Space flight factors may be divided into those which are constant (including weightlessness and galactic ionizing radiation), those which are intermittent (acceleration, vibration, and noise occurring during the most active stage of the flight), and those which are variable. The primary variable factors are parameters of the atmosphere of the spacecraft, such as temperature and humidity, and composition of the atmosphere, especially the presence of trace elements. These factors are particularly important for genetic monitoring. Although they are the most important environmental components, their variability makes them difficult to evaluate.

The most important variable factor is temperature. The role of temperatures in physiological and genetic processes of living organisms is unquestioned. Even relatively small and short-lived changes in temperature may have a noticeable effect on physiological and genetic parameters. The significance of temperature with regard to frequency of chromosomal dislocations is demonstrated, for example, by data such as the following: during Salyut-5 flights the induction frequency of restructuring in lettuce seeds was 0.90%; after exposure to temperature of 50°C for 3 days it was 1.17%. After space flight, the frequency of dislocations in generative cells of tradeskantsia never exceeded 3%, yet after temperature increased to 37°C for 1 hour the frequency of anomalous tetrads reached 6%.

P651 (15/88) Kostina LN, Balayeva AV, Anikeyeva ID, Rusin SV.
Study of mutability of plants exposed to the effects of HZE particles in experiments on board Salyut-6 and with an accelerator.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages:317-318.

Genetics, Mutations, Mitosis
Botany, Air-dried Seeds, Arabidopsis, Crepis capillaris
Space Flight, Salyut-6; Radiobiology, HZE

Abstract: Under space flight conditions, heavy charged (HZE) particles and hadrons of high and superhigh energy, as well as weightlessness, are ecological factors which are unfamiliar to terrestrial organisms. Attempts have frequently been made to associate certain biological effects observed in flight with bombardment by HZE particles. However, the existing data has not demonstrated a clear correlation between bioeffects and hits by HZE. We conducted experiments with air-dried seeds on Salyut-6 and on the ODIYaI accelerator in the city of Dubna in order to determine the link between the inactivating and genetic effects of HZE with the location of their tracks in the seeds. Irradiation of Arabidopsis thaliana seeds by a stream of carbon ions in an accelerator led to a decrease in the fertility of the plants growing from the irradiated seeds, and an increase in the frequency of recessive mutations in the offspring, regardless of the amount of fluence and whether the seeds were hit by the ions. Crepis capillaris seeds in flight and in simulation experiments showed decreased frequency of cell division in the root meristem and increased frequency of chromosome restructuring. However, the small number of seeds hit by HZE in the experiment on Salyut-6 did not permit establishment of a clear correlation between this damage and hits by HZE. In the accelerator experiment, despite the large number of seeds and hits by carbon ions, we were also unable to establish a correlation between biological effects and numbers of hits and fluence of carbon ions. Effects were noted in some seeds in the absence of hits by carbon ions, which suggests that secondary proton radiation plays a significant role in the formation of the observed radiation effects. The absence of a correlation between number of hits by HZE and radiation effects shows the influence of fluctuations in absorbed energy in sensitive areas of the cells on the occurrence of damage.

P649(15/88) Akatov YuA, Maksimova YeN, Marennyy AM, Nevsgodina LV.
Study of the effects of radiation factors on biological subjects in flight experiments on Salyut-6 and Salyut-7 space stations.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 305-306.

Radiobiology, HZE, Biological Effects, Genetics, Aberrant Cells
Botany, Lettuce
Space Flight, Long-term, Salyut-6, Salyut-7

Abstract: Research utilizing plastic physical detectors on Cosmos-936, -1129, and -1514 allowed us to study the radiobiological effects of heavy charged particles (HZE) hitting seeds and cysts of estuary shrimp. The data obtained indicated the presence of certain disruptions of the structure of higher plant seed cells (chromosome aberrations) and also of changes in stages of growth of crustaceans hit by HZE. In a number of cases radiation effects were also found in biological subjects not hit by HZE which may have been associated with the effects of unrecorded radiation.

Because of the small amount of fluence (mean of 4.5 particles/cm^2 for particles with z>6 and linear energy transmission > 200KeV/g/cm^2) it is difficult to obtain statistically reliable data on the effects of HZE for short-term flights (up to 20 days). For long-term flights (up to a year and more) the probability of being hit by a large number of particles with a wider spectrum of heavy ions increases.

The goal of the present work was to study the effects of radiation factors (including individual hits by HZE from galactic radiation) on air-dried lettuce (Lactuca sativa) seeds during long-term flights on Salyut-6 and Salyut-7. Radiobiological effects were assessed by noting occurrence of aberrant cells in the anaphase and telophase of initial mitosis. The seeds were exposed in space for 40, 66, 123, 201, and 457 days.

Results of dosimetry using thermoluminescent detectors showed that when flight duration increased from 40 to 457 days, the magnitude of absorbed dose increased from 3.2 to 63.4 mGy., while fluence of HZE increased from 4.8 to 44.2 particles/cm^2.

Based on cytogenetic analysis of sprouts from irradiated seeds, it was established that the frequency of aberrant cells and cells with multiple chromosome aberrations increased significantly in seeds flown in space for 201 and 457 days. In addition, for virtually all flight durations, the frequency of aberrant cells was significantly greater (by a factor of at least 2) in seeds hit by HZE than in those not hit. This suggest that HZE ions of galactic radiation are highly effective.

Occurrence of aberrant cells and cells with multiple aberrations is a linear function of duration of seed exposure from 40 to 457 days. Rate of increase in the number of cells with multiple aberrations exceeds the rate

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of increase in the number of aberrant cells; the largest numbers in both cases occur in seeds which have been hit by HZE.

P685(15/88)* Aliyev AA, Nechitaylo GS, Novruzova ZA, Ragimova GK, Aleksperov UK.
Modification of cytogenetic, anatomical, and physiological changes in cells and organs of sprouts by biologically active compounds after long-term space flight.
Zhurnal Obshchey Biologii.
XLVIII (6): 723-727; 1987.
[18 references; 6 in English]
Authors' Affiliation: Botanical Institute, Azerbaijan Academy of Sciences, Baku

Botany, Cytogenetic, Anatomical, Physiological Changes; Germination Rate, Growth Rate, Mitotic Activity
Botany, Welsh Onion, Air-Dried Seeds
Space Flight, Long-Term, Salyut-7; Natural Aging; Biologically Active Compounds, Auxin, Alpha-tocopherol

Abstract: Air-dried seeds of the Welsh onion (Allium fistulosum L.) were flown on the Salyut-7 space station for 522 days. A control group of seeds was kept under laboratory conditions on the ground for an equivalent period. Both groups were sprouted in a constant temperature container at a temperature of 25°C in Petri dishes, in water and in solutions of biologically active compounds (BAC: $1 \cdot 10^{-2}$ and $1 \cdot 10^{-4}$ug/ml alpha-tocopherol and 1 and $1 \cdot 10^{-1}$ug/ml auxin). After 1 day, a portion of the seeds was replanted in a special container and cultivated on an ionite medium under normal indoor conditions. On day 10, the height of each sprout was measured, and cross-sections were obtained of the upper, middle and lower parts of the leaf for anatomical analysis. The other half of the seeds were allowed to continue growing in the constant temperature environment; 65 hours after the experiment began apical meristems were fixed for cytogenetic analysis in an alcohol-vinegar solution. In addition, the germination rate of the seeds and rate of growth of the radicle (determined using differential kinetic curves based on terminal differences) were recorded.

Differences in sizes of organs and structural components were noted between the flight seeds sprouted in water and control seeds. Greatest differences were found in the diameter of a cross section of leaves, and in height and width of the conducting bundle. Addition of BAC to the medium of flight seeds increased these parameters; however, only when alpha-tocopherol was used in the higher concentration did they reach the level of control parameters. Addition of BAC to the control medium led to statistically insignificant increases in the measured parameters. Flight seeds grown in water had significantly shorter conducting bundles than controls. Addition of BAC increased the length of the bundle in flight seeds, with the higher concentration of alpha-tocopherol being the most effective agent. Only alpha-tocopherol had a significant effect on control seeds. The authors conclude that alpha-tocopherol has a universal effect as demonstrated by its nonspecific modification of the width and height of the conducting bundle in both the experimental and control conditions. Auxin's effect, on the other hand, is specific, as demonstrated by the effect on the width of the conducting bundle in the experimental, but not the control condition. Long-term space flight had a negative effect on the viability of the seeds after 65 hours of sprouting. While seeds stored for a similar period in the laboratory also showed decreased germination rate, there was a significant difference between the two groups. Addition of alpha-tocopherol to the

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sprouting medium increased the germination rate in both the control and experimental conditions, especially in the smaller dose. Nine sprouting seeds from each group with radicle length of 1 m were planted in Petri dishes containing each of the solutions used in other conditions, and radicle length was measured after 6 or 62 hours. Alpha-tocopherol increased height of control shoots as a function of concentration, but had no significant effects on height of experimental shoots. Storing cells on the ground for 522 days led to a significant increase in genetic damage to the cells of the apical meristem. The effects of natural aging and space flight on mutations were found to be additive, although the increase attributable to flight was small. Addition of biologically active compounds to the nutritive medium reduced mutations almost to baseline level in both the experimental and the control groups. In the control condition, natural aging was associated with a significant decrease in mitotic activity. Space flight factors had an additive effect on this decrease. Addition of alpha-tocopherol increased mitotic activity in both groups, while auxin increased proliferation to slightly above baseline. The authors conclude that the effects of long-term space flight on Welsh onion seeds are almost totally neutralized by addition of biologically active compounds.

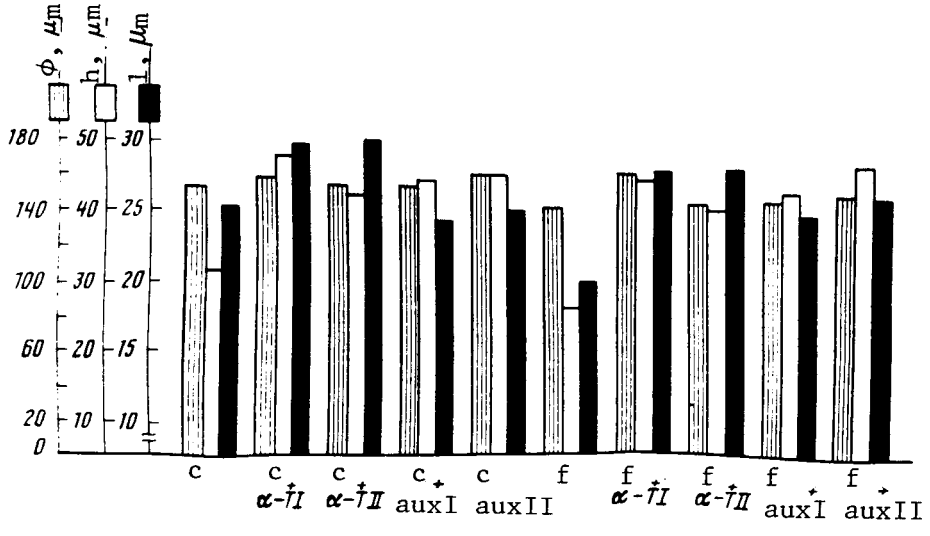

Figure 1: Modification of anatomical changes in control (C) and flight (F) sprouts of Welsh onion by alpha-tocopherol (α-TI $1 \cdot 10^{-2}$ug/ml; α-TII $1 \cdot 10^{-4}$ug/ml) and auxin (Aux I 1; Aux II $1 \cdot 10^{-1}$). Ordinate: diameter of cross-section of leaves (ϕ), height of conducting bundle (h), width of conducting bundle (l): Abscissa - experimental conditions.

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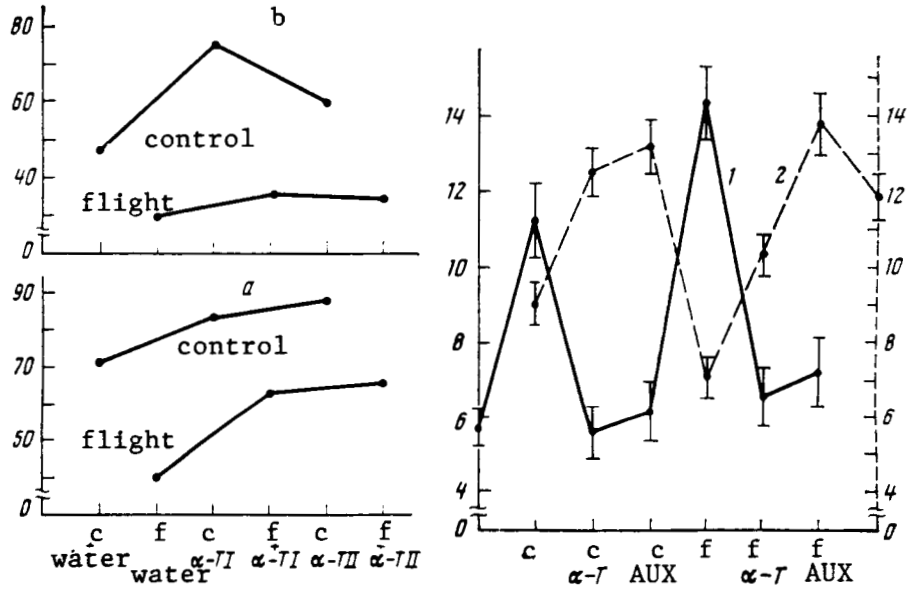

Figure 2: Degree of modification of germination rate (a) and height of sprouts of seed (b) of control (C) and flight (F) Welsh onion seeds by alpha-tocopherol. Ordinate: a - germination rate, %; b - sprout height, mm; abscissa - condition.

Figure 3: Modification of aberration rate and mitotic activity in cells of control (C) and flight (F) seeds of Welsh onion by alpha-tocopherol and auxin. Ordinate - 1 - chromosome aberration rate, %; 2 - level of mitotic activity, %; Abscissa - conditions.

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

PAPERS:

P623(15/88) At'kov OYu, Fomina GA.
Results of echocardiographic measurements during a graded exercise test on a 237-day space flight.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 10-11.

Cardiovascular and Respiratory Systems, Echocardiographic Parameters
Humans, Cosmonauts
Space Flight, Long-Term, Salyut-7; Physical Exercise Tests

Abstract: Over the course of a 237-day flight echocardiographic measurements were made for 2 cosmonauts while they participated in provocative tests involving graded physical exercise. The purpose of these tests was to investigate the effects of exercise on general and local hemodynamics and the contractile capacity of the myocardium when fluid shifts had occurred. The studies used the Soviet "Argument" apparatus and information was transmitted to Earth for processing and analysis by means of television channels. Each cosmonaut participated in 6 graded exercise tests of the PWC_{170} type. An echocardiogram of the left ventricular cavity was recorded for the 2 crewmembers in a state of rest before testing began, during minute 5 of the first stage of the test, during minutes 1 and 5 of rest between the exercise session, minute 5 of the second stage of the test, and minutes 1 and 5 of the recovery period.

In analogous studies performed preflight, both cosmonauts displayed increased end diastolic and decreased end systolic volume of the left ventricle during exercise. Stroke ejection increased by 27-45% with respect to the baseline, minute blood circulation volume increased due to increased heart rate and increased stroke ejection. Hemodynamic responses to graded physical exercise were of the so-called "athletic" type.

During the flight both cosmonauts displayed similar patterns of central and overall circulation in response to exercise. At rest before the test both showed decreased filling volume of the left ventricle; changes in stroke ejection were insignificant, and minute volume was virtually unchanged. During exercise, stroke ejection was less than it had been under the same loading preflight (by 30 and 25%). Increased minute volume during exercise could be attributed to increased heart rate and was lower (by 13 and 15%) than preflight increases.

Lower values for stroke ejection (compared to preflight levels), evidently are not the result of degradation of the functional state of the myocardium, since parameters of myocardial contractile capacity were even higher than preflight. Evidently, the magnitude of stroke ejection was limited by the

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diminished filling volume of the left ventricle. The rapid heart rate during exercise was a compensatory response with regard to stroke ejection, and not an indicator of increased relative difficulty of exercise. The most probable explanation for the changes observed is decrease in the volume of circulating blood leading to some decrease in venous return of blood.

P624(15/88) At'kov OYu, Fomina GA.
Hemodynamic status of members of the third Salyut-7 prime crew in response to an LBNP test.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages 11-12.

Cardiovascular and Respiratory Systems, Hemodynamics, Echocardiography, Myocardium
Humans, Cosmonauts
Space Flight, Long-Term, Salyut-7, LBNP

Abstract: Echocardiography was used to study hemodynamic response to a provocative LBNP test in 2 crewmembers. Pre-, in- and postflight tests were administered. Echocardiograms were recorded of the aorta, left auricle, and cavity of the left ventricle before the beginning of each test, in the last minute of each LBNP application, and in minutes 1 and 5 of the recovery period.

Preflight response to LBNP included increased heart rate. Both cosmonauts displayed decreases in left auricle size, end-diastolic volume of the left ventricle, and stroke ejection. The ejection fraction remained constant. Circulatory minute volume decreased insignificantly at LBNP of -35 and -45 mm Hg.

The values of the echocardiographic parameters were below preflight levels for both cosmonauts at rest inflight, while inflight values were close to preflight during exposure to LBNP. Heart rate was more rapid inflight both at rest and in response to LBNP. Because of this, in the majority of LBNP tests made inflight, circulatory minute volume was higher than the comparable preflight value. In one cosmonaut minute volume decreased proportionally to LBNP during inflight tests. In the other, minute volume decreased during the initial portion of the test, but increased (accompanied by further heart rate increase) at LBNP of -45 mm Hg. In both cosmonauts inflight ratio of left ventricular filling to stroke ejection remained constant both at rest and during all LBNP tests. Thus, no indication of decreased myocardial contractility was observed. The changes in hemodynamic response to LBNP observed during flight were retained in the early postflight period.

Evidently, the high values of heart rate and minute volume (accompanied by normal hemodynamic and myocardial contractility parameters) observed inflight in response to LBNP can be interpreted as a compensatory reaction to support cerebral blood supply when tonus of peripheral vessels is reduced. The echocardiographic data obtained implies that the orthostatic intolerance observed after long-term flight is not caused by worsening of the functional state of the myocardium.

P625(15/88) Bayevskiy RM, Barsukova ZhV, Semenova TD, Tazetdinov IG.
Use of mathematical analysis of cardiac rhythm to evaluate the functional state of cosmonauts performing EVAs.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages 12-13.

Cardiovascular and Respiratory Systems, Cardiac Rhythm, Mathematical Modeling, Adaptation
Humans, Cosmonauts
Space Flight, EVA, Salyut-7

Abstract: Increase in the number of electrophysiological parameters recorded for cosmonauts performing EVA presents some methodological and technological difficulty. For this reason it is important to use data analysis procedures which make it possible to derive more extensive and detailed information about cosmonauts' functional state from additional analysis of the parameters already recorded. Methods for mathematically analyzing cardiac rhythm deserve particular attention here, since they make it possible to evaluate the state of the autonomic nervous system and subcortical neural centers.

This paper describes an instance of the use of mathematical analysis of cardiac rhythm for evaluating the functional state of members of the third Salyut-7 crew during EVA. This crew performed 6 EVAs, including 3 during a 7-day period.

EKG signals were telemetrically transmitted to a computer for on-line computation of pulse rate, stress index for regulatory system and amplitude of slow cardiac rhythm waves for each 100 cardiac contractions. Mean values of these parameters for each EVA period made it possible to draw conclusions about the physiological "cost" of adapting to EVA conditions. In one of the most difficult and labor-intensive EVAs, the mean values of pulse rate, stress index, and slow wave amplitude for the crewmember doing the majority of the work were: 128±12 beats/minute, 886±12 units and 0.167±0.007 units; baseline data were: 78±3 beats/min, 110±6 units, and 0.080±0.002 units, respectively. Analogous values of the same parameters in another EVA were: 105±10 and 68±4 beats/min., 261±16 and 93±11 units, and 0.21±0.005 and 0.190±0.003 units. These data make it clear that activity of the regulatory systems was substantially higher in the cosmonaut performing the greater amount of work.

In studying the mechanism through which the body adapts to EVA conditions, it is of great interest to analyze these parameters for repeated EVAs. Thus, over the first 3 EVAs by the crewmember performing the majority of the work, increase in pulse rate (from EVA 1 to 3) was only slight (100±7 and 115±12 beats/min.), while the stress index increased from 193±17 to 495±24 units, and slow wave amplitude increased from 0.190±0.011 to 0.230±0.009 units. In the other crewmember, who performed less work, pulse rate increased significantly (from 66±4 to 78±4 beats/min), stress

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increased from 61±7 to 138±11 units, while slow wave amplitude decreased from 0.280±0.003 to 0.130±0.007 units.

As these data show, the crewmember performing more work not only displayed higher pulse rate and stress index than the other, but also showed changes in slow wave amplitude which were opposite in direction. During repeated EVAs he displayed an increase in this cardiac rhythm parameter, which decreased in the other cosmonaut. It is well known that increase in slow wave amplitude reflects activation of subcortical neural centers, which results in involvement of additional physiological regulatory systems in the process of adaptation. Thus, we may speak of the formation of a new functional system in response to repeated performance of strenuous work during EVAs.

Using F.Z. Meyerson's concepts of the mechanisms of short- and long-term adaptation, we can consider the data obtained as evidence of the specificity of the functional regulatory systems of the body. Either short- or long-term adaptation mechanisms may come into play as a function of number, duration, and frequency of EVAs. In the latter case, along with the sympathetic nervous system, which is responsible for short-term adaptation, other levels of regulation may be involved in the process of controlling physiological functions, forming a new functional system specific to the particular type of activity. Thus, this methodological approach makes it possible to use available information (EKG) and on-line computer processing to draw conclusions concerning adaptation to performance of work during EVA.

P627(15/88) Itsekhovskiy OG, Alferova IV, Turchaninova VF, Polyakova AP, Golubchikova ZA, Domracheva MV, Volgin VA, Talavrinov VA, Kulev AP.
Study of circulatory system response to a provocative two-stage test using a bicycle ergometer in cosmonauts on a 237-day flight.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 66-67.

Cardiovascular and Respiratory Systems, Circulation; Physical Work Capacity
Humans, Cosmonauts
Space Flight, Long-Term, Physical Exercise, Provocative Test

Abstract: Participation of a physician cosmonaut in long-term space flights has made it possible to modify the methodology for performing tests with graded physical exercise by adding another graded stage of exercise. The new schedule has the following form: baseline - 2-3 minutes, stage 1 of exercise 800 kgm/min - 5 minutes, rest - 5 minutes, stage 2 exercise - 950-1040 kgm/min - 5 minutes, recovery period - 5 minutes. A total of 17 tests were performed. In the majority of cases the following circulatory parameters were recorded: heart rate, parameters of blood pressure and circulating blood volume. Stroke and minute volumes were recorded only during baseline, stage 1 and rest period, because of the short duration of the radio communications session. Data on heart rate and blood pressure were measured every minute during stage 2 exercise and the recovery period and transmitted to Earth by the physician-cosmonaut or another member of the crew. PWC(170) was used as one criterion for evaluating work capacity.

Examination results showed that during the flight the maximal value of heart during both stages of exercise did not differ significantly from preflight value in one cosmonaut, while in the others it was 9-22% higher in one or two of the tests. These latter 2 crewmembers showed other signs of decreased functional reserves in the circulatory system: duration of the transitional warm-up period increased, along with ratio of heart rate to loading. These changes were most pronounced during the second stage of exercise and the recovery period. Decrease in PWC(170) compared to preflight levels (by 16-18% in one cosmonaut, and 10-19% in the other) were also noted.

During the first minute of rest, all cosmonauts showed lower minimal and mean (of systolic and diastolic) blood pressure inflight than preflight. During this period value of stroke volume also changed: in two cases it was elevated and in the other depressed, compared to values before the test. The absolute magnitudes and relative increases in minute volume after stage 1 exercise were always below preflight values. In the few instances where hemodynamic parameters were measured after stage 2 exercise, stroke volume decreased more than after stage 1 exercise. Data from a phase analysis of the cardiac cycle showed that myocardial contractility did not undergo significant change in any cosmonaut.

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Thus, the use of a two-stage test on a bicycle ergometer helped to identify some decrease in physical work capacity in two cosmonauts at different stages of the flight. These decreases may have resulted from a relative deficit in circulating blood volume. The two-stage test generated additional information concerning the reactions of the cardiovascular system to physical exercise.

P628(15/88) Kotovskaya AR, Lyamin VR, Turbasov VD, Vil'-Vil'yams IF, Andreyeva VG, Antonenko LV, Vlasova NF, Galle NN.
A study of cardiac bioelectric activity (EKG-DS) in members of Salyut-7 prime and visiting crews during launch and reentry.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 78-79.

Cardiovascular and Respiratory Systems, Cardiac Bioelectric Activity
Humans, Cosmonauts
Space Flights, Long and Short-Term, Salyut-7, Launch, Reentry, Acceleration; Psychology, Emotional Stress

Abstract: In manned space flight the most pronounced physiological response occurs in cosmonauts during launch, EVA, and reentry. Thus, the study of physiological response to launch and reentry is of great interest. The major factors during these periods are acceleration and emotional stress.

We studied the bioelectric activity of the myocardium during launch and reentry as a function of duration of cosmonauts' exposure to weightlessness (from 8 to 237 days) and their participation in previous space flights. We studied electrocardiograms of cosmonauts, using DS leads, during the flights of the 3 prime and 5 visiting crews of Salyut-7.

Despite differences in absolute values, heart rate dynamics generally followed the same pattern in crewmembers at all flight stages. During the 10-minute "ready" period heart rate increased over baseline (1 month preflight) by a mean of 39%, and by 52% during launch, remaining elevated through the first orbit. Heart rate subsequently decreased, but remained somewhat above baseline throughout the flight. Maximum heart rate during launch reached 120-144 beats/minute in some cosmonauts, and was higher in cosmonauts making their first space flight. In these cosmonauts heart rate increased by approximately 48%, while cosmonauts who had flown previously showed increases of only 27%. This difference in heart rate dynamics during the prelaunch period is, evidently, a consequence of the predominance of the emotional factor, since physical factors, particularly acceleration, were moderate and short-lived.

Before reentry, heart rate increased in all crewmembers, and reached its maximum value upon entry into the dense layers of the atmosphere. Maximum heart rate values reached 152-174 beats/minute in some cosmonauts during this period. During this stage, heart rate response, with rare exception, did not vary as a function of previous space flight experience. Temporal and amplitude EKG parameters were within normal limits. Pathological changes were absent. Comparison of launch and reentry EKGs showed more pronounced sinusoidal tachycardia during reentry. At this stage heart rate did not vary as a function of flight duration.

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Thus, the dynamics of electrocardiographic parameters in crewmembers during launch and reentry can be considered a contributing factor. The more pronounced tachycardia during reentry was to some extent associated with deconditioning after weightlessness and to emotional tension at the final stage of the flight.

P629(15/88) Nikulina GA, Bogomolov VA, Zhernakov AV, Shigoleva TV.
Principles for analyzing the results of dynamic electrocardiograms in the readaptation period following space flight.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 101-102.

Cardiovascular and Respiratory Systems, Dynamic Electrocardiograms
Humans, Cosmonauts, Individual Differences
Space Flight, Short-Term, Long-Term; Adaptation, Postflight Readaptation

Abstract: It is well-known that stabilization of physiological reactions associated with stable adaptation to new environmental conditions does not occur on short-term (7-10 days) space flights. Rate of adaptive restructuring depends on individual differences in reactivity and may be more rapid for individuals showing reactivity of the "plastic" type than for those displaying the "inert" type.

Dynamic electrocardiography is the best method of investigating a cosmonaut's functional reserves the status of his regulatory systems (which are the first to alter in response to new environmental conditions) during the period of readaptation postflight. Dynamic electrocardiography using Holter's method is used clinically to identify and evaluate disruptions of cardiac rhythm and indications of ischemic disease, and also for monitoring the efficacy of treatment. This method has been used in space medicine since 1979.

This method uses a handheld cardiorecorder which makes it possible to record EKG continuously, beginning in the first few minutes after reentry. Records are analyzed with a stationary decoder and microcomputer. One of the major methods for analyzing dynamic EKGs is mathematical processing of a continuous series of cardiac intervals to produce running and hourly values for the major statistical parameters indicative of the state of autonomic homeostasis. The level of tension on the adaptative mechanisms is reflected by the level of activity of the sympathetic portion of the autonomic nervous system. We used the stress index of the regulatory systems to reflect this level. Conclusions were drawn about the functional reserve on the basis of dynamics of hourly parameter values, diurnal changes in statistical cardiac rhythm parameters, and synchronization of parameters reflecting the balance of the sympathetic and parasympathetic systems.

The table presents results of investigations performed on cosmonauts during readaptation following short-term space flights. As this data shows, the amount of adaptive stress cosmonauts display after short-term space flights reflects reactivity type. C1 displays the inert reaction type, while K2, K3, and K4 are very plastic (flexible). No signicant increases in heart rate were observed.

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Under conditions of long-term space flight, a new functional system develops, and the levels of functioning of individual systems change, as does interaction of the central and autonomic mechanisms controlling physiological functions. Consequently, during the early period of readaptation, physiological reactions depend not only on individual reactivity type, but on the state of regulatory systems and the degree to which functional reserves have been maintained.

The use of dynamic electrocardiography during the initial period of readaptation makes it possible not only to determine the chronological biological profile of possibly occult deviations in the regulation of cardiac rhythm or bioelectric cardiac activity, but also to evaluate individual reactions of functional systems and obtain additional information about the status of autonomic regulation and adaptive potential of the circulatory stysem. The entire set of additional data obtained may be used to optimize the motor activity regimen in the early readaptation period.

Table: Results of the mathematical analysis of cardiac rhythm (hourly values) in cosmonauts before and after flight

Cosmonaut	Preflight		Postflight	
	Heart rate	Stress index	Heart rate	Stress index
C1	57.3±0.5	53.0±4.6	66.0±1.4	67.0±6.2
C2	61.0±5.9	45.9±3.1	97.1±3.2	336.0±87.1
C3	40.8±2.1	35.8±9.0	91.9±3.1	136.0±14.1
C4	76.1±2.8	107.0±11.3	86.2±2.6	657.0±12.1

P631(15/88) Turbasov VD, Golubchikova ZA, Lyamin VR, Romanov YeM.
Results of electrocardiographic examinations of Salyut-7--Soyuz prime crews.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Page: 143.

Cardiovascular and Respiratory Systems, Electrocardiography
Humans, Cosmonauts
Space Flight, Long-Term, Salyut-7

Abstract: Electrocardiographic examination is one of the most important components in the arsenal of methods used to evaluate cosmonaut health during space flight. EKGs of cosmonauts belonging to the 3 prime crews of Salyut-7--Soyuz were recorded using the 9 traditional leads (3 standard and 6 chest) using the "Aelita-01" apparatus. Preflight EKG examination revealed no deviations from the norm. In space, there was a general tendency for heart rate to increase moderately as duration of exposure to weightlessness increased. Cardiac rhythm remained sinusoidal. One cosmonaut showed a periodic migration of the lead rhythm (wave) within the limits of the sinusoidal pattern. The majority of cosmonauts displayed occasional increase in the level of sinusoidal arrythmia, when RR exceeded 1/3 of the RR interval. These periods, as a rule, coincided with the performance of work involving considerable emotional stress. Disruption of rhythm took the form of individual extrasystoles and occurred rarely -- usually 1-2 extrasystoles during maximum physical exertion or during the first few minutes after exertion. Inflight, certain cosmonauts displayed changes in the ratios among cardiac biopotentials -- the ratio of R/S peaks increased in the right chest leads and decreased in the left.

The most common changes in all cosmonauts involved repolarization. These changes mainly involved amplitude and form of the T-wave, which generally decreased in amplitude, with accompanying alteration in the ratio of values for the right and left chest leads. The changes noted in cardiac bioelectric activity were functional in nature. Their occurrence may be associated with redistribution of blood, changes in neurohumoral regulation, fluid-electrolyte metabolism, and accompanying changes in myocardial metabolism typical of long-term exposure to weightlessness.

On the whole, the data from electrocardiographic examinations performed during space flight increasing in duration testifies to the maintenance of the cardiac muscles in satisfactory functional condition and confirms that further increase in the duration of space flight is possible.

P641(15/88) Badakva AM, Bazunova YeG, Kulayev BS, Chamurliyev GG.
Dynamics of central circulation and external respiration parameters in a monkey during space flight.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 263.

Cardiovascular and Respiratory Systems, Central Circulation, External Respiration
Primates, Monkey
Space Flight

Abstract: Impedance plethysmography was used in flight and ground-based control conditions to study dynamics of stroke volume, circulatory minute volume, volume of fluid in the chest cavity, respiratory volume, and respiration rate in a monkey. Disk shaped electrodes 9 mm in diameter and made of biologically inert material were implanted subdurally. Current bearing (exploring) electrodes were located on the head and at the base of the tail, while dispersing (indifferent) electrodes were placed above the jugular notch and xiphoid process of the chest.

The signals which were measured -- base resistance between the electrodes, fluctuation in respiratory resistance and results of differential plethysmography -- were recorded on magnetic tape every 2 hours for periods of 5 minutes throughout the experiment. The period during which the monkey's motor activity was minimal in each section (as reflected by respiratory rhythm and absence of artifacts on the plethysmogram) was selected for analysis. Using the procedure of synchronous accumulation, the mean of 20 cardiac cycles on the plethysmogram curve was obtained from the EKG R-wave and used to determine fluctuation amplitudes and cardiac ejection periods. For the same segment we determined base resistance, heart and respiration rate, respiratory volume in arbitrary units, and conditional minute respiratory volume. Using the value of specific resistance of blood obtained in the control condition, 149 Ohm cm, we calculated stroke volume and minute blood volume. Volume of fluid in the chest was calculated from changes in base resistance in comparison with the corresponding value during the control period. To eliminate random components in the dynamic measurement caused by lack of control over the monkey's behavior, we used symmetrical curve smoothing in three dimensions. To identify slow signals in the dynamic measurements we used smoothing in 12 dimensions for 24 hours.

During the initial days of the control study and in the prelaunch period, changes in stroke volume, heart rate, and minute circulatory volume showed no marked diurnal pattern combined with gradual decrease in cumulative average for daily values, evidently reflecting gradual attenuation of emotional excitement related to restraint and confinement in the capsule. During the first day of the flight, values of the parameters and their diurnal variations continued to decline. From the end of day 1 to the end of day 2 of flight, minute circulatory volume increased due to increases in stroke volume and heart rate. Subsequently, these parameters decreased,

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followed by a second wave of increases in heart rate and minute circulatory volume. The diurnal pattern altered on day 2 of flight and remained pronounced throughout flight.

Thus, reactions of the circulatory system developed in the context of changes in parameters characteristic of transition from a state of psychological excitement (stress) to a state characteristic of monkeys immobilized in chairs, and showed 2 phases. However, dynamics of fluid in the chest was not correlated with changes in the parameters just discussed; changing at the beginning of the flight and staying at a somewhat elevated level until the beginning of day 2 of flight. Fluid volume increased until the end of day 4 and only then began to decrease. Analogous changes occurred in respiratory volume and minute respiratory volume, while respiratory rate began to decrease at the end of day 1, showed a significant decline toward the end of day 3, and reached prelaunch levels by the end of the flight.

The two phases of changes in circulation and inflection points in respiratory parameters parallel changes in oxygen pressure in the atmosphere of the capsule. Comparison of the dynamics of circulation and respiration with the partial oxygen pressure curve suggests that changes in the mean level of partial oxygen pressure in the capsule atmosphere affected the values and dynamics of the parameters studied. This effect may result from decline in the activity of arterial hemoreceptors, due to an increase in oxygen saturation in the blood and decreasing sensitivity of the respiratory regulator.

P660(15/88)* Abrosimov SV, Zhidkov VV, Endeka DK, Lobachik VI, Korol'kov VI, Il'in YeA.
The effects of space flight factors on blood circulation in primates.
Kosmicheskaya Biologiya i Aviaskosmicheskaya Meditsina.
21(5): 10-13; 1987.
[8 references; 1 in English]

Cardiovascular and Respiratory Systems, Circulation
Primates, Rhesus Monkeys
Space Flight, Cosmos-1667

Abstract: This paper describes a study of hemodynamic effects on 2 rhesus monkeys exposed to space for 7 days on the Cosmos-1667 biosatellite. Factors studied at rest and during provocative tests included: blood and plasma volumes and erythrocyte mass; parameters of central, peripheral, and organ hemodynamics, and characteristics of blood distribution among regions. The major method used radioactive isotopes as tracers. A special apparatus was developed for performing radiometry of the monkeys' entire bodies in order to obtain quantitative data on distribution and shifts of blood. Animals were examined preflight, 1 1/2 hours postflight and 4 months postflight.

Preflight examinations showed that most parameters were within physiological norms for animals of that species and age; however, blood, plasma, and erythrocyte volume were lower in the experimental than in control animals, possibly due to preflight prophylactic treatment with antibiotics. Lean body mass decreased somewhat in both animals postflight. [Note: values for the animal named Verny will always be given first and those for Gordy second.]Quantity of blood decreased by 3.1% and 2%, attributable to decrease in plasma by 9.4% and 6.8%. Erythrocyte mass remained above preflight level in both subjects. Parameters of central hemodynamics reacted differently in the two animals, as shown in the table. Quantitative measurement of blood distribution with animals at rest in a horizontal position showed similar reactions in both animals postflight. Blood pooling in the chest decreased by 73.5% and 78% compared to baseline, and increased in the abdominal region by 14% and 3%. Blood pooling in the legs increased significantly in both animals. Rate of blood flow in the lungs was also measured. In Verny, blood volume in the lungs and circulation time, and thus blood perfusion in the lungs remained at preflight level. In Gordy, circulatory blood volume in the lungs was 5% above preflight, while pulmonary circulation rate increased by 13% without significantly affecting blood perfusion. Blood flow in the skin of the upper and lower portions of the body was reduced postflight by 65 and 40%, while blood flow in the muscles of the upper and especially lower limbs increased by 142% and 165%. Orthostatic and head-down tilt tests were performed. Both animals tolerated the orthostatic test satisfactorily postflight, however responses were different than preflight. In the baseline period blood shifted from the upper to the lower portion of the body in this test in both animals. Postflight, due to increased blood content in the muscles of the lower limbs, the extent of these changes decreased in Verny, while in Gordy, who showed greater increased blood in the muscles, blood shifted to the abdominal cavity during the orthostatic test. Response of both monkeys to head-down tilt position decreased noticeably. No changes were found postflight in linear blood flow in the vessels of the brain. Four months postflight all parameters had normalized.

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Table: Parameters of central and peripheral hemodynamics in monkeys before and after a 7-day space flight

Monkey	Period	MV, l/min	SV, ml/s	PBT, sec.	PBV, ml	TPR, d·cm·sec^{-2}	BP, mm Hg	HR, bpm	BFT, sec.
Verny	Baseline	0.5	3.3	4.36	25	1610	100.7	153	7.25
	Postflight	0.51	2.7	4.35	26	1480	95.6	190	7.0
Gordy	Baseline	0.61	3.2	3.75	39	1365	99.8	190	6.75
	Postflight	0.78	3.7	3.25	41	1070	96.5	210	6.0

Key: MV - minute volume; SV - stroke volume; PBT - pulmonary blood flow time; PBV - pulmonary blood volume; TPR - total peripheral resistance; BP - blood pressure (mean); HR - heart rate; BFT - blood flow time heart-head

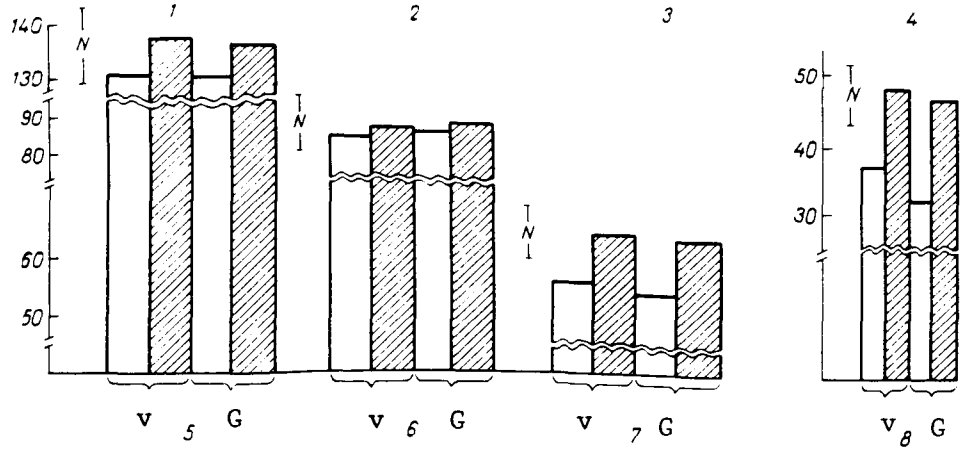

Figure 1: Blood volume parameters (in ml/lean body weight) in the monkeys Verny and Gordy preflight and in the recovery period
1 - circulatory blood volume; 2 - circulatory plasma volume; 3 - circulatory erythrocyte volume; 4 - venous hematocrit. White bars - preflight; cross-hatched - postflight; V - Verny; G - Gordy, N - norm

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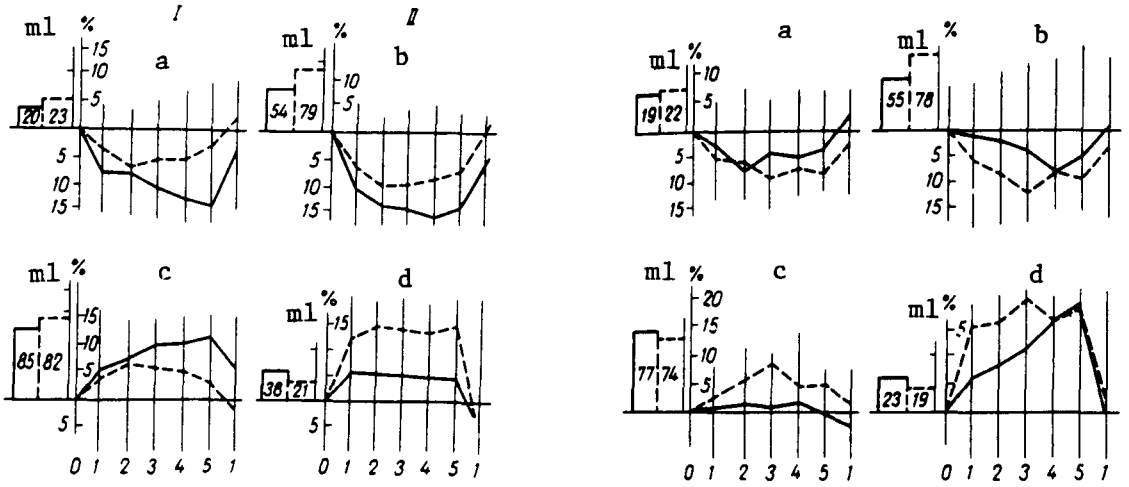

Figure 2: Plasma shifts in Gordy during orthostatic test (in % of baseline) a - head; b - chest; c - abdomen; d - lower limbs; 1 - preflight; 2 - postflight; Left of graph - preflight volume of of plasma in region (in ml). Abscissa - duration of test (in min), arrows - horizontal position

Figure 3: Plasma shifts in Verny during orthostatic test (in % baseline)

P673(15/88)* Strongin GL, Turetskaya AS, Gel'man BL, Rodionov ON.
Predicting complications of cardiovascular disease in flight crews.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 57-62; 1987.
[14 references; 4 in English]

Cardiovascular and Respiratory Systems, Complications, Prognosis
Humans, Flight Crews
Operational Medicine, Diagnostic Prediction

Abstract: The goal of this study was development of a prognostic rule applicable to members of flight crews in civil aviation on the basis of a longitudinal clinical study of personnel who continued to fly and those who did not. A total of 636 clinical examinations of 292 individuals over a 20-year period served as a data base. At the beginning of the project, 91 individuals (mean age 39) were diagnosed as "healthy"; 116 individuals (mean age 48) were diagnosed as suffering from arteriosclerotic disease of the aorta and heart; and 85 (mean age 36) as suffering from neurocirculatory dystonia of the cardiac type. A total of 42 parameters were culled from the examination data, laboratory test results, and medical histories of the subjects.

During the study period, unfavorable outcomes (sudden death, heart attack, etc.) occurred in 14% of the cases. These occurred in 3.4% of the individuals initially diagnosed as healthy, 10% of those with neurocirculatory dystonia, and 26% of those with arteriosclerotic disease. Individuals pronounced fit to fly in the flight certification examination were significantly less likely to suffer from unfavorable outcomes than those not permitted to return to work. The certification exam decreased by a factor of 2 the frequency of acute cardiovascular complications in active members of flight crews. Three groups of parameters for predicting cardiac problems were identified. The first group contains indicators with relatively high prognostic value (54%) and specificity (98%) but low sensitivity (23%); thus, their presence was a strong indicator of likelihood of unfavorable outcome, but their absence did not neccessarily predict a favorable one. The most important indicators in this group were ischemic depression of segment ST at rest and in response to Master's two-step exercise test. The second group contains indicators with satisfactory prognostic value (25-31%), sensitivity (31-52%), and specificity (76-87%). This group contains ischemic depression of the ST segment during submaximal loading on a bicycle ergometer, increase in diastolic blood pressure above 100 mm Hg., hypertrophy of the left ventricle, and a family history of heart disease. These factors make a significant contribution to predicting both favorable and unfavorable outcomes. The third group contains indicators with high sensitivity (56-83%), but low (but significant) prognostic value (19-21%) and specificity (36-62%). This group includes nonspecific changes in segment ST and T wave at rest; expanded contour of the heart to the left, a muffled tone during ausculation, elevated beta-lipoproteins in the blood (above 800 mg%), increased body weight index, smoking, and absence of regular physical exercise. These indicators are common among flight personnel with both favorable and unfavorable outcomes and have auxilliary prognostic utility. A diagnostic table was constructed for predicting the outcome of cardiovascular disease in flight personnel over a 5-year period. In this table each symptom is assigned a value (diagnostic coefficient) the values of each patient's symptoms are added. Once the sum exceeds +90 or

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goes below -130 further summing does not increase prognostic validity. People with sums above 90 have an 80% chance of developing cardiovascular complications in the next 5 years. Sums below -130 are associated with 95% reliability with no such complications. Prognosis for subjects between these two values is not reliable. This table was applied to a new set of subjects with known course of disease and compared with the results of flight certification exams. Flight certification correctly predicted 43% of the cases of unfavorable outcomes while the table predicted 76%. A total of 22% of the flight certified cases developed cardiovascular complications, while only 6% of those for whom the table predicted a favorable outcome developed such complications.

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Table: Diagnostic table for prognosis of outcomes of cardiovascular disease in flight crews in civil aviation (during a 5-year period)

No.	Indicator (symptom)	DC*
1	EKG at rest:	
	ischemic depression of segment ST	+104
	inversion of T wave	+ 37
	decrease of T wave amplitude	+ 1
	ischemic depression of ST segment or T inversion in long-term orthostatic test or normalizing effect of beta blockers	+ 10
	no EKG changes	- 16
2	EKG during exercise	
	ischemic depression of ST segment during Masters two-step test or loading of 500 kgm/min (80 W) on bicycle ergometer	+ 82
	ischemic depression of ST segment during submaximal exercise on bicycle ergometer	+ 64
	ischemic depression of ST, not reproduced after administration of beta blockers	+ 10
	absence of ischemic depression of ST during exercise	- 59
3	Syndrome of enlargement of the left cardiac ventricle:	
	both X-ray and cardiographic signs	+117
	X-ray shows enlargement of left ventricle	+ 80
	hypertrophy of left ventricle on EKG	+ 70
	no cardiac enlargement	- 45
4	Syndrome of physical changes in the heart (percussive expansion of of the border of the heart to the left, muffled tone):	
	present	+ 49
	absent	- 94
5	Heredity:	
	family history	+ 39
	no family history	- 11
6	Diastolic BP during submaximal exercise on bicycle ergometer:	
	more than or equal to 100 mm Hg	+ 52
	less than 100 mm Hg	- 23
7	Diastolic BP at rest:	
	more than or equal to 90 mm Hg	+ 31
	less than 90 mm Hg	- 11
8	Beta-lipoproteins:	
	more than 800 mg%	+ 30
	less than or equal to 800 mg%	- 8
9	Serum cholesterol:	
	more than 260 mg%	+ 22
10	Smoking:	
	smoker	+ 22
	nonsmoker	- 29
11	Physical exercise:	
	none or irregular	+ 11
	regular	- 59

* DC = Diagnostic coefficient; + indicates association with a negative outcome, - with a positive one

P678(15/88)* Krasnov IB, Nosova YeA.
Activity of Ca^{2+}, Mg^{2+}-ATPase myosin in the myocardia of rats after 30-days of exposure to 1.1 and 2-g.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 72-73; 1987.
[17 references; 7 in English]

Cardiovascular and Respiratory Systems, Myocardia, Ca^{2+}, Mg^{2+}-ATPase myosin
Rats
Hypergravity, Centrifugation; Adaptation

Abstract: Myocardia were obtained from animals rotated in a centrifuge at 2.0-g and 1.1-g (peripheral and central groups, respectively) for 30 days. On day 30 of centrifugation and day 2 after its cessation animals in the two experimental and one control group were sacrificed. A fragment of muscle taken from the left ventricle was frozen in liquid nitrogen. Activity of Ca^{2+}, Mg^{2+}-ATPase myosin was measured on the basis of increase in inorganic phosphate after 10 minutes of incubation at 30°C in a medium containing 20 mM imidazol, 50 mM KCl, 2 mM $MgCl_2$, 2 mM ATP, 0.1 mM $CaCl_2$ and 5 mM dithiothreitol with ph of 7.0.

In animals exposed to 2-g, activity of Ca^{2+}, Mg^{2+}-ATPase myosin increased by a factor of 2 compared to the vivarium control. This suggests an increase in rate and amplitude of cardiac contractions under 2-g. On day 2 after treatment Ca^{2+}, Mg^{2+}-ATPase myosin activity had returned to normal for this group. When animals were exposed to 1.1-g, Ca^{2+}, Mg^{2+}-ATPase myosin activity was virtually unchanged. The authors conclude that changes in Ca^{2+}, Mg^{2+}-ATPase myosin activity is one of the molecular mechanisms of myocardial adaptation to altered gravity.

Table: Ca^{2+}, Mg^{2+}-ATPase myosin activity (in nmoles F_n per 1 mg protein) in 1 minute at 30°C in myocardia of rats exposed to increased gravity

Group	Time	
	Day 30 of treatment	Day 2 post treatment
Control	76±10 (5)	68±8 (5)
1.1-g	55±5 (4)	62±6 (4)
2-g	153±37* (7)	76±5 (5)

Numbers in parentheses indicate number of animals. * $p < 0.01$.

P680(15/88)* Modin AYu.
Comparison of orthostatic intolerance after immersion in horizontal and vertical positions.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 77-79; 1987.

Cardiovascular and Respiratory Systems, Orthostatic Intolerance, Deconditioning
Humans, Males
Immersion, Horizontal and Vertical Positions, Tilt Test

Abstract: In this experiment, 6 healthy men were exposed for 3 days to immersion in either a horizontal or vertical position. Each man was immersed in both positions with an interval of 60 days between sessions. One day before immersion and directly afterward, an orthostatic tilt test was performed in which subjects were tilted to a $+70^{o}$ position. Central hemodynamics were studied using impedance plethysmography. Parameters recorded included: heart rate, stroke and cardiac indices. During the baseline period all subjects showed good orthostatic tolerance: heart rate increased by a mean of 25.3% and 25.4% for the two baseline measurements; stroke index decreased by 36% and 40.5%, and cardiac index by 19.7% and 25.4 %. After immersion, regardless of position the orthostatic test led to typical changes in the relationship among cardiac index components, increased heart rate, and decreased stroke index, and virtually unaltered total blood flow volume. Effects of the tilt test were the same in pattern but greater in magnitude after immersion than in the baseline condition. Subjective symptoms of intolerance were also more pronounced after immersion. No evidence was found for differences between the two immersion positions with regard to deconditioning.

Figure: Parameters of central circulation before and after a 3-day period of immersion in horizontal and vertical positions

DEVELOPMENTAL BIOLOGY

(See also: Musculoskeletal and Respiratory Systems: P646; P650)

PAPERS:

P644(15/88) Makeyeva VF, Yegorov IA.
Concentration of nucleic acids and protein in the mother-fetus system of rats after space flight.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 285-286.

Developmental Biology, Mother-Fetus System, Metabolism, Nucleic Acids and Protein; Reproductive Biology
Rats, Female, Pregnant
Space Flight,Cosmos-1514

Abstract: Nucleic acids play a leading role in metabolic processes in animals. In order to understand the biochemical processes involved in the effects of space flight factors on the mother-fetus system, we studied the concentration of nucleic acids and proteins in certain organs of rats undergoing space flight in the third trimester of pregnancy and the resultant offspring at various times during postnatal development (days 1, 15, 30, 100). The concentration of nucleic acids in tissues was determined spectrophotometrically using Blobel and Potter's method, and the concentration of protein using Lowrey's method.

On day 18 of pregnancy after space flight, concentration of DNA in the livers of female rats remained unchanged, while concentration of RNA was somewhat elevated compared to control level, which is possibly related to development of a compensatory reaction serving to support the normal development of the fetus under exposure to extreme conditions. The concentration of protein remained at normal level. The concentrations of nucleic acid and protein in the placentae of the flight group remained at the same level as that of the vivarium control. Concentrations of nucleic acids and protein in the uteri of flight and synchronous rats increased after flight in comparison with the vivarium group: DNA by 27%, RNA and protein by 14%. Since there were no differences between the flight and synchronous groups, these changes may have resulted mainly from the contributing factors present in space flight, rather than weightlessness itself. Space flight had no discernible effect on the levels of nucleic acids and protein in fetuses on day 18 of prenatal development.

The results of this study of the concentration of nucleic acids and protein in the liver of fetuses and neonate animals showed a slight increase in DNA and RNA in the flight group in comparison to the vivarium control. Thus the concentration of DNA (mg/g dry tissue) in the liver of the flight fetuses was 9.2 ± 0.4, and 8.2 ± 0.3 in the control. The comparable figures for neonate animals were 4.3 ± 0.2 in the experimental group and 3.8 ± 0.2 in the control. The concentrations of RNA in the livers of fetuses and neonate rats was

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elevated by 12% and 15%, respectively. Changes in concentration of nucleic acids with age suggest that fetuses and neonate rats of the flight group may suffer from slight developmental retardation. There were no observable effects on the concentration of nucleic acids in the liver of older (15-, 30-, and 100-day-old) flight rats. The magnitude of the RNA/DNA ratio in the flight experiment in all age groups did not differ from the control groups and was lower in the livers of fetuses (2.1) than in adult rats (4.6). No changes in the concentration of protein were found in the liver of offspring of rats exposed to space flight in any age group. This parameter, beginning with birth, gradually increased during the postnatal period of development in rats in all groups.

The results obtained show that the livers of rat fetuses and neonates which had been exposed to space during prenatal development showed only slight changes in the concentration of nucleic acids, which subsequently normalized during postnatal development. Thus, exposure of rats to weightlessness in the third trimester of pregnancy did not have a significant effect on the concentration of nucleic acids and protein in the livers of their offspring.

P663(15/88)* Cherdantseva YeM.
Embryonic development of guppies in weightlessness.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 22-25; 1987.
[10 references; 8 in English]

Developmental Biology, Embryonic Development; Reproductive Biology
Fish, Guppies, Female, Pregnant
Space Flight, Cosmos-1514

Abstract: Subjects in this experiment were 3 pregnant guppies flown on board Cosmos-1514 for 5 days. Control and synchronous groups were used. Temperature and feeding conditions were identical for all groups. Two days after the biosatellite returned to Earth (approximately day 12 of pregnancy), 1 guppy from the flight and 1 from the control group was sacrificed and fixed for further histological analysis; another female from each group was sacrificed 6 days later. One guppy in each group was allowed to give birth normally. In the fish reserved for analysis the abdominal portion containing the ovaries was removed, stained, dehydrated, and made into sections for microscopic analysis. To determine the orientation of eggs within the ovaries, guppies at various stages of pregnancy were fixed and their abdominal cavity dissected and the ovaries analyzed.

The pregnant fish tolerated space flight conditions well. The female allowed to bear young gave birth to 25 normal young and two anomalous underdeveloped embryos. Such stillbirths are not uncommon in guppies maintained under optimum conditions. The control female gave birth to 20 normal young. Birth occurred after 26 and 31 days for the flight and control animals, respectively. Both terms are normal for guppies. The flight guppy was mated again and gave birth after 26 days. Histological examination did not reveal any differences between control and flight embryos. The flight female was dissected during her seventh pregnancy, embryos were found to be completely normal. The 25 offspring of the flight female were interbred and their offspring found to be normal.
Analysis of normal development of guppy eggs in the ovary showed that in all likelihood polarity of eggs does not depend on gravity.

P684(15/88) Olenev SN, Danilov AR, Kryuchkova TA, Sorokina LM, Krasnov IB.
The effects of weightlessness on some brain development parameters (results of exposure of pregnant rats on the Cosmos-1514 biosatellite and study of the subsequent development of their offspring on Earth).
Arkhiv Anatomii, Gistologii i Embriologii.
XCIII(9): 20-25; 1987.
[13 references; 2 in English]
Authors' Affiliation: Leningrad Pediatric Medical Institute
NOTE: Cf. Abstract P593 (Developmental Biology), Digest Issue 14

Developmental Biology, Neurophysiology, Brain Development
Rats, Female
Space Flight, Cosmos-1514

Abstract: Pregnant rats were flown on board Cosmos-1514 for 6 days, starting on day 13 of pregnancy. Some material was obtained for study immediately after landing (18-day-old fetuses), and the rest on days 15, 30, or 90 of postnatal development. Synchronous and vivarium control groups were used. Brains were isolated and fixed, stored at cold temperature, and enclosed in paraffin. A series of cross sections 10 um thick were prepared and every fifth slide stained. The rhomboid brain was processed histochemically and tested for NAD- and NADPH-diaphorase, lactate and succinate dehydrogenase, alkaline phosphatase, acetylcholinesterase, and monoaminooxidase reactions. When an experimental sample differed visually from the norm, cytophotometry was performed. The plaque method was used to study relatively homogeneously stained samples.

No macroscopically observable differences from controls were noted in the brains of 18-day old fetuses of the flight group. The flight group showed enhanced alkaline phosphatase reactions, indicating that vessels in the medulla were finer and more numerous than those in the control group. Although there was a tendency for lactate dehydrogenase activity to be lower in flight rats, this was not statistically significant. Frontal sections of the brains of 18-day-old fetuses were stained with gallocyanin-chrome alum and analyzed for differences between flight and control groups. No differences were detected between flight and control groups in the number of mitoses on an area of the surface of the ventricular cortical matrix. The mean width of the cortical layer measured in medial, dorsal, and lateral sections was greater in the flight than in the control group. The authors hypothesize this might be explained by differences in cellular migration rates. No differences in rate of differentiation of the earliest developing neurons of the ganglion trigeminale were found. Flight groups showed increased area of capillaries in the striatum. When brains of 15-day-old rats were compared, no differences between flight and control conditions were detected.

The authors conclude that such morphogenetic processes as multiplication, migration, and differentiation of neurons; growth of appendages; establishment of neural links; and neuroglial interactions; as well as vacularization are adequate after exposure to space flight and reentry acceleration. The difference in development of brain capillaries brain in flight fetuses may be associated with differences in lactate or cystein. Possibly, changes in hemodynamics associated with flight lead to histochemical differences in nerve cells, which show greater alkaline phosphatase activity.

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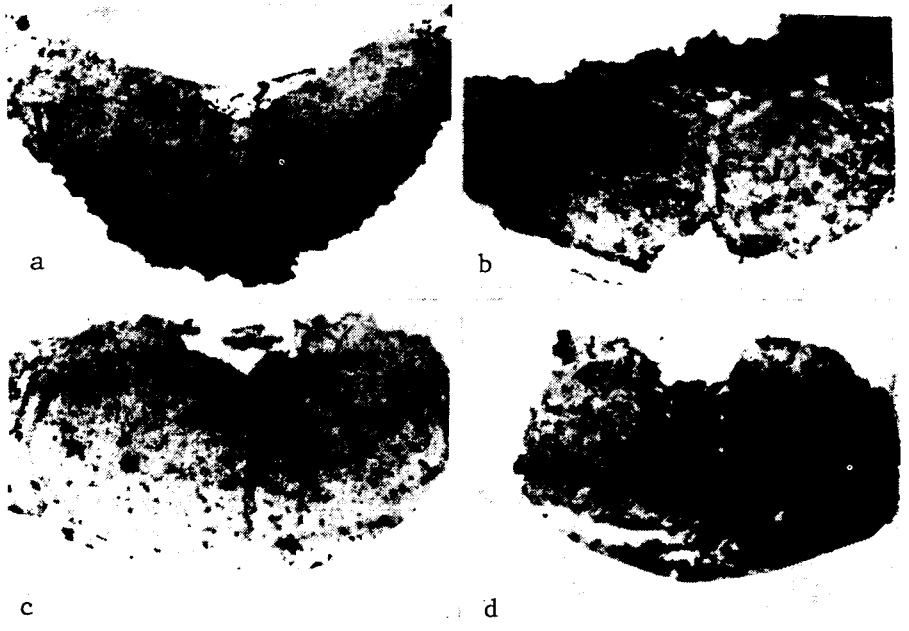

Figure 1: Cross sections of the medulla oblongata in 18-day-old fetuses of control (a, b) and flight (c, d) rats.

Reactions to alkaline phosphatase mainly reflect capillaries and brain vessels. It can be seen that there are more and finer capillaries in flight rats.

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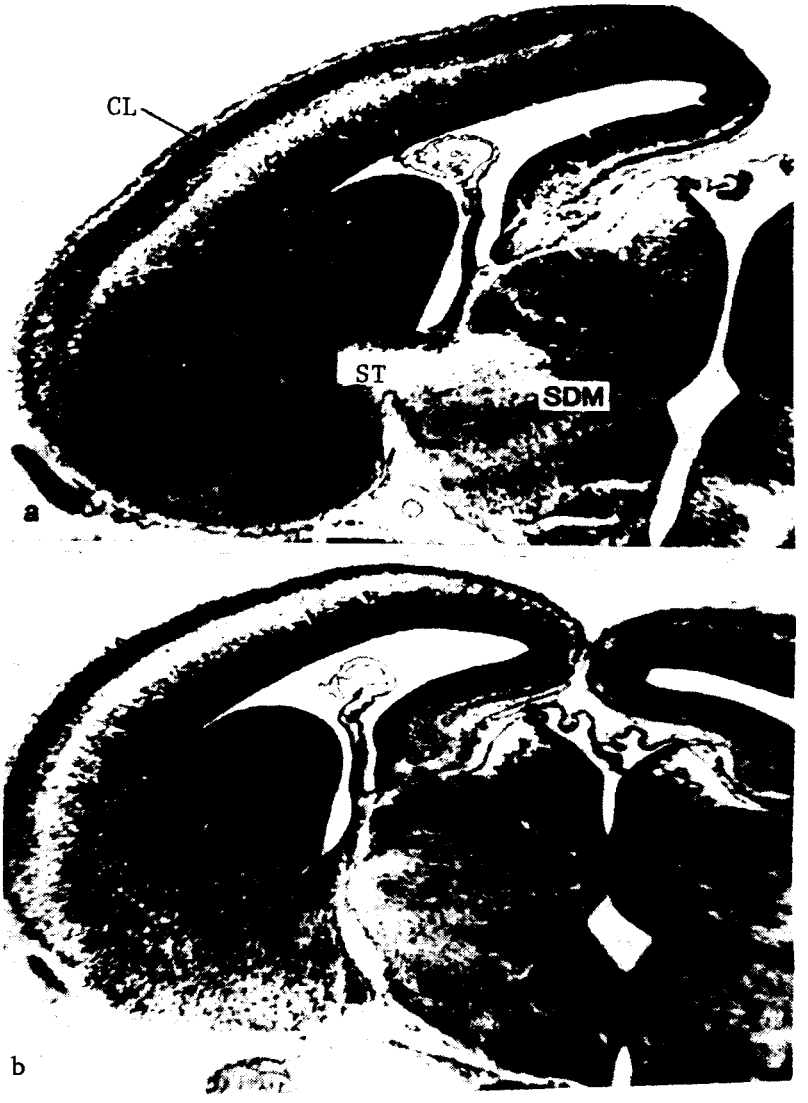

Figure 2: Cross sections of the endbrain and dienecephalon in 18-day-old fetus in the control (a) and flight (b) groups.
CL - cortical layer; ST - striate tuber; SDM - sulcus dencephalicus medialis.

ENDOCRINOLOGY: See Musculoskeletal System: P647; Psychology: P681
ENZYMOLOGY: See Genetics: P666
EQUIPMENT AND INSTRUMENTATION: See Body Fluids: P675; Habitability and Environment Effects: P636

EXOBIOLOGY

PAPER:

P652(15/88) Yurov SS, Akoyev IG.
The possible role of the local radiation factor in space in the creation of the prerequisites for prebiological evolution.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Page: 329.

Exobiology, Prebiotic Evolution; Biospherics
Theoretical Article
Space, Radiobiology, Local Radiation

Abstract: The rapid development of space technology, space biology and medicine, planetary physics, and astrophysics has confronted scientists with a number of broader general biological and theoretical questions, which cannot be solved without fundamental research in all areas of modern science. One of these questions involves the prebiological stage in the development of life in the universe (Earth) and the further influence of extreme physical factors, including electrical storms and vulcanic processes, on the maintenance of various ecological forms of living matter. Study of the Moon first showed the major role played by cosmic radiation in the formation of the physical and chemical features of the surface layers of lunar soil.

We have identified heavy charged particles and hadrons of high and superhigh energy as components of the spectrum of cosmic radiation which could have had effects on evolution. When these entered the primordial air-water environment of Earth the local radiation factor was formed. Instances of strong interaction initiate multiple generations of various secondary particles with a broad energy spectrum and local, extremely concentrated release of energy occurs. Such processes, like ionization, excitation of nuclear desintegration, hydrodynamic impact in the primary aqueous phase, and accompanying UV-radiation, give rise to reaction-active centers of nuclear and physicochemical transformations. These include mesochemical reactions engendering various mesoatoms and mesomolecules, which contribute to the synthesis of many chemical compounds, which in turn participate in the competition occurring during the stage of prebiological evolution. The final consequence was selection of stable forms for further stages of prebiological evolution. The local radiation factor also acted as one of the most powerful extreme physical factors capable of destroying any molecule or chemical system.

GENETICS

(See also: Botany: P643; P651; P649)

PAPERS:

P655(15/88) Filatova LP, Vaulina EN, Grozdova TYa, Lyapteva NSh.
Genetic effects of exposure to space flight in drosophila.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 299-300.

Genetics, Chromosome Nondivergence, Reproductive Biology, Gametes
Insects, Drosophila, Male, Female
Space Flight, Salyut-6

Abstract: In order to determine the effects of space flight factors on the genetic system of animals on board a spacecraft, we analyzed the frequency of chromosome nondivergence in drosophila. Since that organism is relatively sensitive to space flight factors, tests of chromosome nondivergence in miosis in drosophila were replicated more or less continuously from flight to flight.

In our experiment we studied the effects of an 8-day space flight on nondivergence of sex chromosomes in the gametes of male and female Drosophila melanogaster. Male D. melanogaster were exposed on Salyut-6 twice, and females once. The insects were then analyzed in the laboratory. In addition to the flight experiment, males were used in a simulation experiment with simultaneous exposure to vibration and acceleration. In this experiment, males were subjected to the full set of dynamic factors characteristic of the active phase of space flight, as simulated on a vibration stand fitted with a centrifuge. Vibration frequency was 300-800 Hz, acceleration was 6-8 G, duration of exposure was twice for 9 minutes with an interval of 8 days between exposures. A laboratory control group was also used. The temperature in all experiments, including the control, was $24\pm1^{o}C$. The flies were maintained on a David medium.

The results of the experiment showed that space flight factors increase the frequency of nondivergence of sex chromosomes by a factor of 2 in both male and female drosophila. In the simulation experiement with male drosophila it was established that the combined effects of vibration and acceleration do not exhaust the spectrum of mutagenic space flight factors.

Nondivergence of chromosomes in drosophila in response to space flight factors was first noted by N.P Dubina et al., in an experiment on Vostok during a flight of 108 minutes.

Oster and Browning (1971) in their research on drosophila during the flight of Biosatellite-2 demonstrated an increase in the frequency of chromosome nondivergence under the influence of space flight factors. In Oster's work, however, this increase was not statistically significant.

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Dedone and colleagues (19568) obtained proof of destruction of the spindle in microspores in tradescantia under the influence of space flight factors, particularly weightlessness. Their ideas do not contradict those of Oster and Sparrow et al. (1971), who consider weightlessness, along with radiation as the major factors inducing disruption of the formation of the spindle, which leads in drosophila to nondivergence of chromosomes.

There are two hypotheses concerning the nature of chromosome nondivergence in response to space flight factors. One is that disruption of normal chromosome divergence can be explained by structural disorders in the first stage of miosis. An error in chromosome divergence may be induced by radiation and associated with exchanges between nonhomologous chromosomes, which lead to normal orientation of the spindles. This model is challenged by another hypothesis which attributes abnormal chromosome divergence to the effects of weightlessness (possibly in combination with radiation) on the spindle or centromere, followed by its destruction.

Although our results allow us to attribute the effect to the influence of cosmic radiation, they do not rule out weightlessness as one of the major ecological space flight factors.

P665(15/88)* Komolova GS, Zakaznov AV, Makeyeva VF.
The effect of weightlessness on the replicative function of DNA in hepatocytes of rats.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 31-34; 1987.
[8 references; none in English]

Genetics, DNA, Replication, Hepatocytes
Rats
Space Flight, Cosmos-782, -1129, -1667; Immobilization, Stress

Abstract: Male Wistar rats were exposed to space flight conditions on Cosmos series biosatellites. Each flight group had a corresponding synchronous control condition simulating all factors except weightlessness. In simulation experiments with hypokinesia, animals were maintained in immobilization cages; control animals were treated identically but maintained in larger cages. As an additional stress factor, rats were restrained with legs outstretched for 2.5 hours every day for 6 days. Replicative functioning of DNA in the cells of the liver was studied by observing inclusion of labelled predecessors in vivo and in vitro (method not further specified). In all cases we calculated specific radioactivity expressed in impulses per 1 ug of DNA in 1 minute or in percent of vivarium control. Each condition contained 7-10 animals.

Neither long-term exposure to weightlessness, nor sudden transition from weightlessness to normal gravity led to any changes in the DNA-synthesizing activity of hepatocyte nuclei of rats. Simulation experiments involving 22 days of hypokinesia were associated with only a slight tendency to decreased hepatic DNA synthesis. However, several days after return to Earth, DNA replicative function of hepatocytes was depressed by 31% and 39%, depending on flight, compared to vivarium condition and lower than that of the synchronous control. When flight animals were rigidly immobilized for 2.5 hours per day during 6 days of the readaptation period (which gives rise to depressed hepatic DNA synthesis in normal rats), no additive ef two factors occur, suggesting that changes in the genetic apparatus of hepatocytes is a form of chronic stress reaction. There is reason to believe that depression of DNA replication in the liver is the result of changes in level of growth hormone. No changes in hepatic DNA replication were noted after a 7-day flight. Thus, the system being studied is sensitive to transition from long-term weightlessness to 1-g, but not to the reverse transition occurring at the beginning of a space flight. Thus, effects of space flight on this function may be expected to occur primarily during readaptation.

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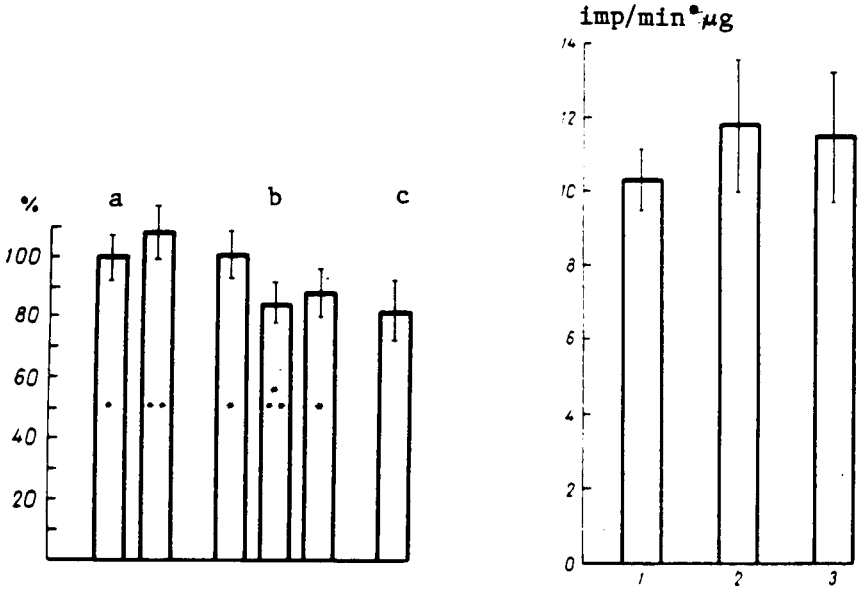

Figure 1: Rate of inclusion of a radioactive precursor in nuclear DNA of hepatocytes of rats after space flights lasting 19.5 days (Cosmos-782), 18.5 days (Cosmos-1129) and a 22-day period of hypokinesia

Ordinate - specific radioactivity of DNA. a - Cosmos-782; b - Cosmos-1129; c - hypokinesia. * - vivarium control, ** - flight; *** - synchronous control

Figure 2: Effect of 7-day flight on Cosmos-1667 on inclusion of a radioactive precursor in nuclear DNA of hepatocytes of rats

Ordinate - specific radioactivity (in impulses per 1 ug per 1 min.); 1 - vivarium control; 2 - synchronous control; 3 - flight.

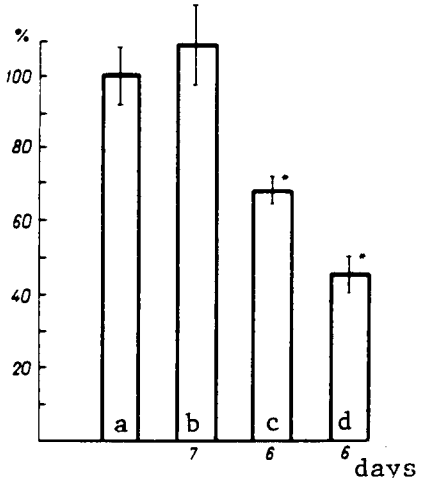

Figure 3: Effect of gravitational stress on rate of inclusion of a radioactive precursor in nuclear DNA of hepatocytes of rats.

Abscissa - number of days; Ordinate - specific radioactivity (in %). a - vivarium control; b - 1-g -> weightlessness (Cosmos 1667); c - weightlessness -> 1-g; d - immobilization; * - difference from vivarium control statistically significant.

P666(15/88)* Makeyeva VF, Komolova GS.
RNA-synthesizing activity in the liver of rats after flight on the Cosmos-1667 biosatellite.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 34-36.
[9 references; 2 in English]

Genetics, RNA-Synthesis, Enzymology, Liver
Rats, Male
Space Flight, Cosmos-1667

Abstract: Subjects in this experiment were male Wistar rats, some of which were exposed to space for 7 days on Cosmos-1667, while the remainder comprised a synchronous control group. Since the flight and synchronous conditions occurred at different times, each group had its own vivarium control. This paper reports mean data from 3-4 measurements made on each of 7 animals directly after the treatment terminated. Nuclei were isolated from liver tissue and some used to measure endogenous synthesis of RNA. The rest were used to generate solubilized nucleotidyltransferase. Synthesis was estimated by measuring rate of inclusion of a radioactive precursor in the acid-insoluble product of the nucleotidyltransferase reaction. The results were expressed in impulses per 1 ug DNA per minute as measured by a liquid scintillation counter. Concentration of nucleic acids was measured spectrophotometrically and expressed in mg per 1 g moist tissue.

Concentration of DNA was significantly lower in the livers of flight rats than in those of the vivarium control. RNA was also depressed to an insignificant extent. Similar but more pronounced effects occurred in the synchronous group. After the flight, transcription activity in synthesis of endogenous RNA was 30% higher than in the vivarium group. Such activity also increased by 17% in the synchronous control. Inclusion rate of the labelled precursor was highest in flight rats. Inhibition of nucleotidyltransferase synthesis depressed inclusion of the label by a like amount in the flight and control groups; thus enzyme activity remained higher for the flight animals in the presence of the inhibitor. This suggests that increased activity for the flight group is associated with both forms of the enzyme (I and II).

The authors argue that since RNA synthesis in the liver is enhanced by exposure to space flight, the tendency for concentration of nucleic acids to decrease must be due to other causes, e.g., hyperfunction of the cytoplasmic cell system, including protein-synthesizing activity serving to activate a number of adaptive enzymes. Results obtained in this experiment are analogous to those found after longer term (18 days) flights.

Table: Concentration of nucleic acids (in mg/g) in the liver of rats after flight on Cosmos-1667 biosatellite

Condition	DNA	%	RNA	%	RNA/DNA
Flight	3.05	85	12.9	93	4.2
Control	3.57	100	13.8	100	3.8
Synchronous	2.70	81	12.1	88	4.5
Control	3.34	100	13.7	100	4.1

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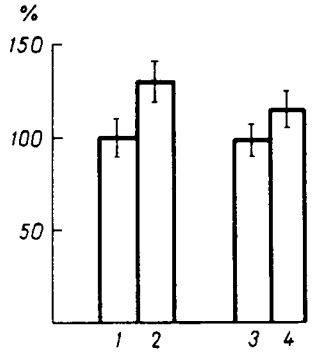

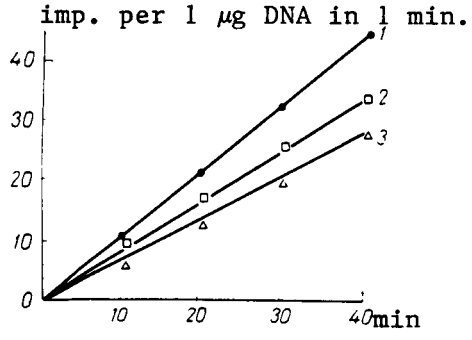

Figure 1: Endogenous synthesis of RNA in nuclei of the liver
Ordinate - inclusion of ^{3}H-UMP. 1 - control for flight; 2 - flight; 3 - control for synchronous group; 4 - synchronous group.

Figure 2: Kinetics of ^{3}H-UMP inclusion in the nucleotidyltransferase system. Abscissa - incubation time at 30°C (1 min). Ordinate - inclusion of ^{3}H-UMP (in impulse to 1 ug DNA per 1 min). 1 - flight; 2 - synchronous control; 3 - vivarous controls.

HABITABILITY AND ENVIRONMENT EFFECTS

(See also: Human Performance: P669; Metabolism: P670)

PAPERS:

P636(15/88) Bizin YuP, Bogatova RI.
Hygienic approaches to evaluating safety during the performance of technological experiments in space.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages 219-220.

Habitability and Environment Effects, Safety
Humans, Cosmonauts
Equipment and Instrumentation, Technological Flight Experiments

Abstract: The solution of complex problems associated with the normal functioning of manned space station complexes is not possible without further expansion and deepening of research in various fields of science. Such investigations will serve as a basis for the creation of new life support systems, technologies, apparatus, and equipment. All this has significantly extended the range of tasks cosmonauts perform while conducting technological experiments. It is clear that flight programs of future long-term space flights will devote a great deal of attention to technological and biotechnological experiments.

An increase in the number and range of cosmonauts' tasks poses the question of adapting many aspects of industrial hygiene to conditions created by hermetically sealed quarters in combination with other specific long-term space flight factors. At present, we have already generated a great deal of material relevant to evaluation of the state of spacecraft atmospheres, and identified a number of regulatory characteristics for individual sanitary and hygienic parameters for long-term space flight. All this may serve as a basis for developing approaches to the evaluation of the safety of technological experiments conducted in space. However, the diversity of technological and biotechnological flight experiments demands the evaluation of specific biological, physicochemical, microbiological, thermal, and other factors which may significantly affect ecological and hygienic habitability conditions and cosmonaut work capacity. The standards and government specifications developed for ordinary industrial situations do not consider the specific features of space flight (limited space, weightlessness, high emotional stress, etc.).

It appears that one of the major approaches to evaluation of the safety of technological experiments in space and the related industrial hygiene issues should involve the development of standards to allow establishment of safety requirements and prevent effects of potentially harmful factors during various stages of development and creation of experimental apparatus, and to decrease their negative effects on human physiology and the environment in hermetically sealed living quarters.

P672(15/88)* Berlin AA, Chekanova SL.
Investigation of the composition of wash water of men and women.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 53-57; 1987.
[4 references; none in English]

Habitability and Environment Effects, Water Reclamation Systems
Humans, Men and Women
Wash Water, Composition

Abstract: A group of 12 men and 12 women, aged 25 to 50, participated in this study. Components of wash water used for showering were analyzed. Showers were taken once in 7 days for an unspecified period, making a total of 500 showers. Subjects were permitted to wash their hands and faces between showers. Distilled water and cleansing agents used for each shower were strictly rationed. Women were allowed to wear cosmetics, perfumes, creams, and deodorants. No mention is made of the men wearing deodorants. The following parameters were studied in the used wash water: biochromatic oxidizability, electroconductivity, hardness, odor, clarity, concentration of cleansing agent, chlorides, ammonia, total quantity of microbe bodies per 1 ml. Women's wash water showed elevated electroconductivity and chlorides compared to men, and slightly lower oxidizability. Certain subjects suffered from colds or elevated blood pressure during the period. Both these factors affected the wash water, with high blood pressure having a stronger effect. Menstruation had only a slight effect on composition of wash water from females. Factor analysis showed 2 factors accounting for most (85%) of the variation in wash water. The first pertained to salt excreted and the second to the sweat glands. Factors identified did not depend on gender, thus the gender of crewmembers need not be considered when designing water reclamation systems for spacecraft. The two factors were best described by 3 parameters: oxidizability, chlorides, and electroconductivity. The highest loading on Factor 1 were electroconductivity and chlorides; oxidizability showed highest loading on Factor 2.

Table 1: Mean and standard deviation of parameters of wash water composition

Group	Oxidizability (mg O_2/l)	Electroconductivity (Cm/cm)	Chlorides (mg/l)
Men	1565 (315)	$1.63 \cdot 10^{-4}$ ($0.83 \cdot 10^{-4}$)	20.54 (9.49)
Women	1431 (312)	$3.17 \cdot 10^{-4}$ ($1.16 \cdot 10^{-4}$)	39.14 (11.35)

Numbers in parentheses are standard deviations.

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Table 2: Relationship between human physiological state and main physicochemical parameters of wash water

Subject #	Health	Oxidizability ($mg\ O_2/l$)	Conductivity (Cm/cm)	Chlorides (mg/l)
1	Cold	1600	$1.8 \cdot 10^{-4}$	19.88
	Normal	1230	$1.9 \cdot 10^{-4}$	18.7
4	Cold	1800	$1.12 \cdot 10^{-4}$	21.3
	Normal	1340	$1.4 \cdot 10^{-4}$	19.2
8	BP 180/110	2300	$6.0 \cdot 10^{-4}$	79.52
	Normal	1200	$4.0 \cdot 10^{-4}$	17.0
11	BP 160/100	2000	$1.58 \cdot 10^{-4}$	15.62
	Normal	1400	$2.34 \cdot 10^{-4}$	9.47
12	BP 160/110	2100	$1.06 \cdot 10^{-4}$	9.94
	Norm	1350	$1.45 \cdot 10^{-4}$	10.8

Table 3: Factor structure of components of used wash water

Figure: Mean parameters describing wash water used by men and women

P679(15/88)* Pashin SS, Ushakov VF, Gorshunova AI, Ostasheva NYe, Stadukhin YeB, Chukhno EI.
Toxicokinetic aspects of use of sulphur hexafluoride in a hermetically sealed environment.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 74-77; 1987.
[15 references; 4 in English]

Habitability and Environment Effects, Toxicology, Hermetically Sealed Environment
Rats, Male
Sulphur Hexafluoride

Abstract: Sulphur hexafluoride has been proposed as a fire extinguishing gas for use in hermetically sealed environments. Conflicting data exist about the potential biological effects of this gas. Research was performed on 45 male white outbred rats and 25 male Wistar rats. The animals were confined in a steel 14-liter chamber. Oxygen mixed with sulphur hexafluoride (SF_6) was blown into the room. Animals were sacrificed for study by eliminating oxygen in the chamber. Concentration of SF_6 in inhaled and exhaled air was determined using chromatography. Chromatography was also performed on thermal evaporation of biological samples.

SF_6 showed low solubility in blood, but accumulated in fatty tissue. Maximum concentration occurred in perirenal fat after 5 hours exposure to a concentration of 80%. Concentration in the tissues of the spine, brain, and blood equalled 14%, 4%, and 0.5%, respectively, of that in the perirenal fat. Concentrations in other organs were equal to or less than that in the blood. Because SF_6 is highly dense it can increase respiratory resistance leading to hypoxemia and hypercapnia, to an extent dependent on physical activity. Because animals breathing air while the majority of their bodies were surrounded by 100% SF_6 showed no accumulation of the gas, the authors conclude that SF_6 can only enter the body through the lungs. Accumulation of SF_6 in the body as a function of inhalation time is initially an S-curve. Accumulation depends on concentration of the substance in inhaled gas, concentration in body, and time. An equation was derived from experimental data which allows computation of the levels of environmental SF_6 which lead to neglible accumulations in the body. Accumulation of SF_6 in fat is a function of concentration in connective tissue, which acts as an intermediary between blood and fat. Investigation of the exhalation rate of SF_6 after 1 hour exposure to a gas with concentration of 70% showed it to be described by the following equation: $C=C_0e^{-0.362}$, where C_0 is initial concentration. After 24 hours no SF_6 was detectable in the animals bodies. In view of the exponential nature of SF_6 exhalation and its short half-life in the body, it can be concluded that its presence in the environment in expected concentration does not represent a major danger. However, repeated high exposure at intervals less than 24 hours may lead to undesirable accumulation of the substance in the body.

Figure 1: Kinetics of accumulation of sulphur hexafluoride in bodies of rats during inhalation

Figure 2: Kinetics of exhalation of sulphur hexafluoride from the bodies of rats after exposure

HUMAN PERFORMANCE

(See also: Space Biology and Medicine: M118)

PAPERS:

P632(15/88) Nechayev AP, Ponomareva IP, Khideg Ya, Bognar L, Remesh P. (last three are Hungarian).
On the additional capacities of the methodology for studying human psychological work capacity (based on Salyut-7 results).
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 191-193.

Human Performance, Psychological Work Capacity
Humans, Cosmonauts
Space Flight, Salyut-7

Abstract: The study of changes in human psychological work capacity has important practical significance in view of the increasing complexity of the operator's job in contemporary monitoring and control systems. This has led industrial and engineering psychologists to intensify the search for information-rich parameters reflecting level of psychological work capacity. For this purpose, Hungarian specialists have proposed a methodology based on determination of such characteristics as amount and rate of information processing, rate and accuracy of motor responses, heart rate, and electrical resistance of the skin. A complex parameter, the "psychophysiological reserve index," is derived from these data and serves as an overall indicator of human psychophysiological capacity. This methodology is implemented using a portable instrument, the "Balaton-M" [Hungary], which processes and records the data for subsequent analysis. The results obtained in the laboratory and from Salyut-6, Salyut-7, and Soyuz flights indicate that the methodology has satisfactory reliability and provides sufficient information.

To gain understanding of the characteristics of operator performance, it is also of interest to evaluate quantitatively the information transmission and attention allocation capacities of humans solving information processing problems varying in difficulty. Transmission capacity characterizes the processes of perception, information processing, and response generation; while rate of information processing is defined in this method as reflecting reactions at the level of the cerebral cortex. Comparison of values of transmission capacity and speed of information processing for the same conditions and period during the investigation, indicated that these parameters are related linearly.

To study the stability of information processing rate in an "overload" condition, the "Balaton-M" device has an information sharing mode in which the operator must simultaneously encode information received through visual and auditory channels. We proposed an additional parameter -- a coefficient varying from 0 to 1 -- which reflects error free encoding of relevant acoustic

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signals. Since the Balaton methodology entails presenting information at increasing tempo, we believe that not only is data for each rate of interest, but so is their mean value and standard deviation.

Using this methodology, psychological work capacity was studied pre- and postflight and also during Salyut-7 flights. Analysis of the results obtained testify to maintenance of an adequate level of psychological work capacity. At the same time, a number of general patterns and individual differences were noted in changes in the parameters studied. These were especially pronounced when task complexity was high. In members of the prime crew, the quantity of processed information when two channels had to be attended to decreased by 4.4% in space (compared to the preflight period), while the standard deviation of this parameter increased by a factor of 2.6. Analogously, standard deviation of the "reserve index" increased by a factor of 3.7, although its mean value remained virtually unchanged. In members of the visiting crew during the preflight period, transmission capacity, as well as mean and standard deviation of the "reserve index," varied as a function of the complexity of the operator's designated task. Capacity to share attention also decreased somewhat (value of the corresponding coefficient decreased from 1.0 to 0.923 and 0.941). On day 2 of flight virtually all psychological work capacity parameters decreased, while on day 9 they reached baseline values. During readaptation there was a tendency for the parameters studied to stabilize and approach preflight values.

Thus, the additional parameters proposed (transmission capacity, coefficient of stability for attention sharing, mean value and standard deviation of the "reserve index") increase the information obtained from analyzing dynamics of human psychological work capacity and are recommended for use with data generated by the "Balaton" methodology.

P634(15/88) Khachatur'yants LS, Ivanov YeA, Yepishkin, AK.
The effect of space flight on the characteristics of pursuit tracking.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 208-209.

Human Performance, Tracking, Pursuit
Humans, Cosmonauts
Space Flight, Voskhod, Soyuz-5, Soyuz-7, Soyuz-T

Abstract: Tracking is the most important type of operator task performed by the cosmonaut. For this reason, from man's first flights in space this task was subjected to thorough and meticulous investigation. The use of the RPS-2M apparatus (to record the tracking process) on flights of the Voskhod, Soyuz, and Soyuz-T made it possible to determine how much space flight factors influenced one of the most important of the operator's capacities -- visual-motor coordination. Thus, the results obtained by PI Belyayev and AA Leonov on the Voskhod-2 showed that the number of errors in manual tracking of sinusoidal signals increased by a factor of 2 or 3. At the same time, the magnitude of errors in flight increased with increasing frequency of sinusoidal signals to a greater extent than on Earth. Initial changes in amplitude-frequency characteristics began to occur in flight with an input signal frequency of 3-4 rad/sec. In further studies performed on Soyuz flights, increases up to 34% were recorded in the reaction time for visual-motor reactions when cosmonauts tracked incremental signals. In addition, it was established that magnitude of tracking errors made by cosmonauts who had flown before was 1.5 to 2 times lower than those made by individuals on their first space flight.

Data from Soyuz and Soyuz-T flights were used to identify phase changes in cosmonaut work capacity linked to adaptive processes, which members of the Soyuz-5 crewmembers, AS Yeliseyev and BV Volynov were the first to observe. The RPS-2M device was used to record data, which indicated that the level of sensorimotor tracking performance decreased precipitously during the first 10 first orbits. Subsequently, decrement in tracking performance slowed, reaching 50-70% of baseline by the end of day 2. After this, the quality of performance increased and stabilized, without returning to its preflight level. The final series of tests with the RPS-2M apparatus were conducted by the second member of the Salyut-7 visiting crew. These differed from previous studies by virtue of improved methodology, which enabled the study of changes in each separate functional component of the operator's visual-motor coordination. In addition, measurements were made not only during the flight itself, but on day 1 after reentry.

Data analysis indicated that tracking errors increased by a factor of 2.5 during flight. After 10 days of orbital flight, the cosmonaut's work capacity was totally restored to preflight level (tracking errors did not exceed data obtained in the training simulator by more than 4-6%).

P669(15/88)* Yastrebov VYe, Kustov VV, Razinkin SM.
Investigation of short-term effects of high concentrations of carbon monoxide on certain psychophysiological functions of a human operator.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 47-49; 1987.
[12 references; 3 in English]

Human Performance, Compensatory Tracking
Humans, Males
Habitability and Environmental Effects, Carbon Monoxide

Abstract: This study used 8 male volunteers, aged 26-40, of whom 3 smoked. These 3 stopped smoking 4 hours before the experiment. Task used to assess human performance was 2-dimensional compensatory tracking accompanied by simultaneous mental solution of problems involving identifying the sum of 2 numbers presented in the peripheral visual field as odd or even. All experiments used a 5-minute preliminary baseline period for recording psychophysiological parameters, followed by a 30-minute experimental session. In the experimental condition subjects were exposed to CO in a concentration of 900+20 mg/m^3, and in the control condition (presumably, the same) subjects breathed ordinary air. Performance measures were an index reflecting errors and signal detection latency in the tracking tasks and rate of information processing in the mental arithmetic task. Before the exposure to CO, subjects were trained until performance of the simultaneous tasks stabilized. Attempts were made to use task instructions conducive to high motivation. Aside from performance parameters, heart rate, respiration rate, and minute respiratory volume were recorded. Immediately after CO breathing stopped in minute 16 of the study there was a 1-minute break in task performance for taking blood to study the concentration of carboxyhemoglobin. Other blood samples were taken before and immediately after the experiment. Carboxyhemoglobin in blood was determined photometrically. Change in physiological parameters was determined by examining oxygen pulse, defined as the ratio of change in respiratory minute volume between baseline and experimental conditions to change in heart rate.

Breathing of CO decreased tracking task performance in 3 subjects including one smoker. Worst performance occurred in minute 30 of task performance (25 minutes after beginning of CO breathing). Decrease in mental arithmetic information processing rate was not statistically significant. An increase in performance level during the experimental condition is attributed to the pause for taking blood. HbCO was 1.6% in baseline, 10% in minute 15% and 6.6% in minute 30. No significant differences were observed in the oxygen pulse parameter, probably because this parameter increased in the control session possibly due to stress. Five of the 8 subjects complained of mild physiological symptoms during breathing of CO. The authors argue that these results are of significance for aerospace medicine.

Figure 1: Change in the rate of processing information during performance of a tracking task while breathing air and air mixed with CO

Figure 2: Change in the level of tracking performance while breathing air and a mixture of CO and air

Figure 3: Adaptation of heart rate to metabolic level of work during performance of a tracking task while breathing CO

PAPERS:

P640(15/88) Teplinskaya GP.
The effects of space flight factors on the functional activity of T-lymphocytes responsible for delayed hypersensitivity.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 259

Immunology, T-lymphocytes, Allergy, Delayed Hypersensitivity
Humans, Cosmonauts
Space Flight, Long-term, Short-term, Salyut-7; Hypokinesia with Head-Down Tilt

Abstract: Research has shown that space flight factors may have an adverse effect on the human immune system, particularly on the T-system. Attenuation of immunological capacity of the body leads to an increase in susceptibility to infections, including infection by one's one microflora. Development of hypersensitivity to a particular agent or fragments of it plays an important role in the complex process of interaction between infectious agent and the host body. In the overwhelming majority of cases the development of an allergic reaction makes any infectious process worse, impeding the usual method of treatment.

The goal of this work was the study of the effect of long-term space flight and also long-term hypokinesia with head-down tilt on the functional activity of specific T-lymphocytes responsible for delayed hypersensitivity.

Examinations were made of members of prime crews spending 75, 96, 140, 150, 175, 185, 211 and 237 days in space (14 people); a total of 13 members of visiting crews who had spent 7-8 days in space; and 21 subjects participating in a 120-day experiment involving hypokinesia with head-down tilt. We measured formation of lymphokines, inhibiting migration of leukocytes (LIF factor) in the presence of allergens, typical representatives of human automicroflora (streptococcus, staphylococcus, intestinal bacillus and Proteus). We used a modification of the micrometria method developed by AA Polner.

Long-term exposure to space flight induced increased sensitivity to bacterial allergens in 5 of 14 cosmonauts. Four showed sensitivity to streptococcus allergen, and 1 to staphylococcus allergen. After long-term hypokinesia with head-down tilt, 5 of 21 subjects showed sensibilization to allergens of the major representatives of human automicroflora. After 2-3 months of hypokinesia, 2 subjects developed hypersensitivity to staphylococcus allergen, and 3 to both staphylococcus and streptococcus allergens.

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Thus, long-term exposure to space flight factors, and also to long-term hypokinesia with head-down tilt, a ground-based model of certain effects of weightlessness, may induce changes in human allergic status, increasing sensitivity to certain representatives of normal automicroflora of the skin and mucous membranes. The data obtained demonstrates the need for prophylactic measures to decrease the risk of allergic complications arising during space flight.

LIFE SUPPORT SYSTEMS

(See also: Microbiology: P638; Nutrition: P637)

PAPER:

P635(15/88) Abakumova IA, Gur'yeva TS, Dadasheva OA, Lebedeva ZN, Tresvyatskaya Na.
Future prospects for using nontraditional food sources in human biological life support systems.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages:214-25.

Nutrition, Nontraditional Food Sources, Plants, Fly Larva
Rats
Life Support Systems, CELSS

Abstract: One of the major problems that must be solved in the creation of closed ecological systems is coordination of trophic links within the system. These must provide maximal and highly efficient use of energy, as contained in the substances synthesized in the system, and full recycling of their elements. This issue must be resolved for every model of a system, whatever its structure and degree of closure. The "human-plants-mineralization" system models currently being proposed contain a small number of species and have a simple trophic structure. In these models 50% of the biomass of higher plants are not traditionally used [as food]. This biomass, as well as several other components of the CELSS, have chemical structures close to those traditionally used for food. Thus, the protein content of the biomass of house fly larva is 50%, while juices from the cormophytic mass of higher plants are 19-30% protein, and chlorella biomass is 50% protein (dry weight). Digestability in vitro of these protein sources is 40% for house fly larva, 34% for a mixture of juices extracted from the cormophytic mass of higher plants, and 42% for chlorella biomass.

Experiments performed on white rats investigated the possibility of partial (10% of protein) replacement of casein by protein from such nontraditional products as extracts from the cormophytic mass (juices and tops) of higher plants, biomass of one-celled algae (chlorella), and house fly larva.

The diets of the experimental and control groups contained the same number of calories with protein content of 10% and 18%, respectively. The animals were fed once a day and given water ad lib. The experimentors observed not only the general state of the animals and their weight, but also the state of total protein, protein fractions of blood serum, and protein metabolism, as indicated by renal excretion of such nitrogen fractions as total nitrogen, urea, amino nitrogen, creatine, and creatinine. At the end of the experiment the animals were sacrificed and their visceral organs studied histologically.

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At the conclusion of the experiment, the weight of animals given the experimental diet did not differ significantly from that of the control group. The quantity of food eaten by the animals and analysis of excrement enabled us to compute the percentage assimilation of the diets studied. Animals receiving a diet composed of a mixture of juices extracted from plants consumed less food than the control group rats, 66% and 74%, respectively. Assimilation of nitrogen was also lower in the group receiving the experimental ration (mixture of plant juices and casein), comprising 81% compared to 98% in the control group. This was confirmed by biochemical study of animals' urine and blood. The animals receiving the diet consisting of casein and plant juices showed a tendency toward reduced renal excretion of urea in comparison to the control group (54.7 ± 15.0 mg % and 70.9 ± 9.4 mg %, respectively).

Analysis of blood serum for total protein and protein fractions in animals of the experimental and control groups revealed no deviations from the norm. However, total protein in the serum of animals fed a diet containing biomass of house fly larva was somewhat higher in globulin fractions compared to controls.

Histological studies of the visceral organs of rats fed rations which partially replaced casein protein with vegetable proteins revealed no differences. However, inclusion of house fly larva in the diet led to fatty degeneration of the liver, which, evidently, is associated with the high concentration of fat in the biomass of lower heterotrophic organisms.

Thus, the experimental data showed that inclusion in animals' diet of juices of the tops of higher plants and biomass of one-celled algae did not negatively affect their general state or protein metabolism. The use of nontraditional food sources in a human CELSS would increase the percentage of usable biomass and thus raise the efficiency and recycling capabilities of the system.

MATHEMATICAL MODELING: See Biological Rhythms: M119; Cardiovascular and Respiratory Systems: P635; Neurophysiology: P668

METABOLISM

(See also: Developmental Biology: P644; Musculoskeletal System: P656)

PAPERS:

P654(15/88) Popov IG, Latskevich AA.
Sulphur-containing amino acids in blood plasma of cosmonauts.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 357-358.

Metabolism, Amino Acids, Cystine, Methionine
Humans, Cosmonauts
Space Flight, Long-term; Nutrition, Cosmonaut Rations

Abstract: Of the 17 amino acids in blood plasma which are usually studied in cosmonauts pre- and postflight, those containing sulphur, methionine and cystine, deserve particular attention, since these are essential nutrients important in metabolism of many proteins. When physiological functions are stressed the need for such substances may increase. However, level of these amino acids in the body is frequently limited by external factors, such as their limited content in many foods, destruction during processing and storage, or less than optimum diet which decreases their assimilability, etc.

In the course of examinations on day 1 after flights lasting 21, 48, 140, 175, 185, and 211 days, some decrease (compared to baseline) in the concentration of methionine was found in 9 cosmonauts, while decrease in cystine was found in 11 of 12 cosmonauts.

In order to clarify the role of diet in changes in amino acid status observed in cosmonauts postflight, we studied dynamics in the concentration of methionine and cystine in blood plasma of 6 men who received rations given to cosmonauts on "Salyut-5" for 30 days. Samples of venous blood were studied every 5 days with the Hitachi-KLA-36 automated analyzer. The rations contained an average of 98 g protein, 137 g fats, 317 g carbohydrates, with consumption of 2980 calories/day. In the majority of rations, concentrations of methionine and cystine were established at the minimal level for obtaining nitrogen balance. Energy consumption of the subjects was within the limits of occupational group I as defined in the physiological norms of nutrition adopted by the USSR in 1982.

On days 15-30 for the majority of subjects, the concentration of methionine decreased from a mean of 0.34±0.01 mg % to 0,30±0.01 mg% (in 4 of the 6, decreased concentration was noted starting on day 5), while concentration of cystine dropped from 0.79 to 0.70 mg %. On day 10 of the rehabilitation period, the concentration of methionine increased to a mean of 0.32 ± 0. 01

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mg%, remaining below baseline in the majority of subjects. Concentration of cystine reached baseline level on day 5, i.e., recovered faster than methionine, possibly due to increased synthesis.

These data imply that rations consumed by cosmonauts may play a definitive role in reduction of concentration of sulphur-containing amino acids in cosmonauts' blood plasma. This suggests that the concentration of amino acids in the rations should be treated as an important ecological environmental factor, which affected amino acid status and the course of biochemical processes in cosmonauts.

P670(15/88)* Savina VP, Vlasova TF, Miroshnikova YeB.
Glutaminic acid in blood of humans exposed to an atmosphere with elevated ammonia content.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 50-52; 1987.
[20 references; 5 in English]

Metabolism, Glutaminic Acid
Humans
Habitability and Environment Effects, Ammonia, Hermetically Sealed Environment

Abstract: In this study, 4 subjects spent 20 days under relatively normal conditions, 6 days in a hermetically sealed space breathing ordinary air, 37 days in the hermetically sealed environment with an atmosphere which contained gradually increasing concentrations of ammonia eventually reaching 2 mg/m^3, followed by a 6 day follow-up period under normal conditions. Other atmospheric parameters in the experimental condition were: CO_2 not exceeding 0.4-0.6%, O_2 - 19%; air temperature 20^o. Subjects ate a standard diet. Blood was taken on an empty stomach once in the baseline period, on day 6 in the hermetically sealed environment before introduction of ammonia, on days 6, 13, 25, and 37 of the ammonia breathing period, and once on day 6 of the follow-up period. Free amino acid concentration in the blood was determined. Baseline data showed a number of deviations from the norm in the amino acid concentration of subjects' blood, which the authors attribute to emotional stress. Parameters remained unchanged up until day 37 of exposure to ammonia. At this time, concentration of glutaminic acid increased significantly and alanine showed a tendency to increase. During the follow-up period, glutaminic acid remained significantly above baseline, and valine showed a tendency to increase.

Table: Concentration of free amino acids in blood plasma of subjects living in a hermetically sealed environment

PAPERS:

P638(15/88) Zaloguyev SN, Viktorov AN, Shilov VM, Bragina MP, Il'in VK, Kuprin YuN.
Ecological aspects of formation of microflora in spacecraft cabins.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 233.

Operational Medicine, Human Automicroflora
Microbiology
Life Support Systems, Ecological Systems, Hermetically Sealed Environment, Spacecraft Cabins

Abstract: The ecological system that develops within a hermetically sealed spacecraft cabin has virtually all the features inherent in terrestrial ecological systems, along with a number of specific distinguishing features. These are associated with the need to artificially create the atmosphere with abiotic components (generation of oxygen, elimination of carbon dioxide and harmful chemical components) and the presence of two biological components: humans and microflora. The latter circumstance causes the ecosystem to be unstable, since a change in one component disrupts the whole ecosystem. Continuous exposure of cosmonauts to space flight factors, especially weightlessness, leads to certain changes in the functioning of a number of systems and organs which, without a doubt, are reflected in their automicroflora. For this reason, study of the interaction of humans and microorganisms under these conditions is of interest not only on a practical medical level, but also from the standpoint of biology, since information will be generated concerning the formation of ecosystems relevant to all artificial living situations.

It was established that there was an increase in the total quantity of microbes on cosmonauts with dysbacteriotic changes in the composition of automicroflora. Environmental microflora of the space station was composed of the cosmonaut's automicroflora. Among the microorganisms growing on the cosmonauts' skin and detected in the environment, there was an increase in the proportion of representatives with pathogenic properties and those resistant to antibiotics. No direct correlation was observed among changes in these parameters, suggesting that they are spontaneous and independent and that variability of microorganisms under such conditions is not only a result of their interaction with humans, but a consequence of restructuring of biochemical processes within the microbial cell.

A characteristic of the interaction between humans and microorganisms under these conditions is "microbial pressing" resulting from the effects of environmental microflora on the formation of human automicroflora or as a result of interchange of microbes between individuals. This process, which

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results in colonization by microorganisms which are not indigenous to the given individual, may lead to a decrease in the antagonistic activity of automicroflora with regard to a number of pathogenic microbes. This was noted in cosmonauts during long-term inhabitation of Salyut space stations.

P639(15/88) Il'in VK, Moroz AF, Bragina MP, Antsiferova NG, Glatman LI, Semeyking LA.
Certain aspects of changes in drug sensitivity of human automicroflora during space flight.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Page: 234.

Microbiology, Drug Sensitivity
Human Automicroflora, Conditionally Pathogenic Microorganisms
Space Flight

Abstract: A number of studies have shown that the role of conditionally pathogenic microorganisms is increasing as a source of various infectious processes in humans. The possibility of endogenous infections developing under the specific living conditions of crews of manned spacecraft is of particular significance.

Bacteria possessing extrachromosomal (plasmid) resistance to multiple drugs are particularly dangerous, since this resistance would decrease or completely negate the efficacy of antibacterial drugs. As our research has shown, direct exchanges of strains with multiple resistance factors (R-plasmids) occurs during space flight. The possible development of endogenous infections in cosmonauts during space flight requires updating and expansion of the drug arsenal, and introduction of new antibiotic reserves and drugs acting on conditionally pathological microflora, yeast-like fungi and other microbes. With these goals, in addition to evaluating microbial status, we also studied the sensitivity spectra of conditionally pathogenic microorganisms cultured from cosmonauts before and after space flights varying in duration to 20 antibacterial drugs.

Analysis of results of examination of 70 cosmonauts showed that in both the pre- and postflight periods, there was broad dissemination of cultures of conditionally pathogenic microorganisms with resistance to antibiotics. Cultures taken from cosmonauts postflight showed increased resistance to antibacterial drugs. At the same time, it should be emphasized that resistance to antibiotics on the part of the cultured microorganism did not increase for certain antibacterial preparations (biseptol [bactrim], oletetrin [1 part oleandomycin phosphate, 2 parts tetracyclin], levomytsetin [chloromycetin] and others).

In our paper we consider the possible mechanisms through which conditionally pathogenic microorganisms develop resistance to antibiotics during space flight.

PAPERS:

P626(15/88) Grigor'yeva LS, Chekirda IF, Stepantsov VI, Kozlovskaya IB.
(Evaluating the) effects of weightlessness on the work capacity of the muscles of the arms.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 45-46.

Musculoskeletal System, Work Capacity, Arms
Humans, Cosmonauts
Space Flight, Salyut-7

Abstract: Expansion of the number and variety of tasks performed by cosmonauts during space flight makes it essential that, aside from evaluating overall work capacity, we also investigate the state of individual muscle groups. This work addresses questions related to evaluating the effects of weightlessness on the functional state of the muscles of the hands and arms.

To achieve this goal we used an arm bicycle ergometer and dynamometry of the hands. On the ergometer, subjects were required to pedal with their arms at a submaximal loading until the point of fatigue. The loading was assigned by instructing subjects to maintain a pedalling rate of 60 revolutions/minute, as indicated by a speedometer. The work performed was 940 kgm/min. While subjects were taking the tests, EMGs were recorded for the working muscles of the upper arms and forearms and an EKG was also registered. Recording EMGs made it possible to monitor the level of muscle fatigue during the test. The work capacity of the muscles of the arm were evaluated on the basis of amount and duration of work performed, taking account of maximal values of heart rate and the time required for resting heart rate to be reestablished after the test was terminated. Manual dynamometry involved determination of the maximum strength and static and dynamic endurance of the forearm muscles. Endurance was defined as the maximum length of time a subject could sustain work 75% of maximum loading: in the static mode by holding a given load; and in dynamic mode by developing it at a rate of once a second. Schedules for manual dynamometry were developed on 8 volunteers of both sexes, while bicycle ergometer schedules were developed under simulation conditions in a water tank with 8 male operators before and after performance of a given amount of work. The effects of weightlessness were studied during long-term space flights (211 and 237 days) on the Salyut-7 space station.

Results of our studies showed that maximum time to perform the test involving manual pedalling averaged 1.5-2.5 minutes, amount of work performed fluctuated between 1600-2400 kgm, and maximum heart rate during the test varied within the group from 144 to 166 beats/minute. Objective signs of muscle fatigue were observed in the EMG in an interval from 1 to 2

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minutes after beginning work. Evaluation of amount of participation of various muscle groups in the pedalling showed that the most work while pedalling away from oneself (about 60% of maximum force) was performed by the extensor muscles of the upper arm, while the least work (30-40%) was performed by the tensor muscles of the upper arm and the forearm. Study of static and dynamic endurance using manual dynamometry showed that the maximum time for performing the test varied from 20 to 50 seconds in the static mode and from 0.5 to 1.5 minutes in the dynamic mode. These studies were used to develop test schedules for on-line evaluation of the functional state of the muscles in the arm in weightlessness.

P642(15/88) Bakulin AV, Il'in YeA, Rezayeva LT, Khodskevich YuN, Artamasova YeM.
The state of bone tissue in pregnant rats after a 5-day space flight on the Cosmos-1514 biosatellite.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages:265-266.

Musculoskeletal System, Bone Tissue, Mineral Component
Rats, Female; Reproductive Biology, Pregnancy
Space Flight, Cosmos-1514

Abstract: Osteoporosis, developing during experimental unloading of the skeleton, involves not only decrease in bone mass, but also characteristic changes in the composition of the mineral component of bone tissue. We conducted an investigation of the contents of the mineral component of bone, the elements it contained, and the mechanical characteristics of spongy bone tissue in pregnant rats after a 5-day space flight. These animals were 13 days pregant at the point the flight began. The animals were divided into 3 groups: space flight, synchronous control, and vivarium control. The conditions of the experiment are described in detail in Serovaya et al. (1985) [Abstract P12 /Reproductive Biology/ Digest Issue 1.] The mechanical characteristics of the proximal epiphysis of the humerus during compression was tested using the "Instron" machine. A set of mechanical properties was derived from the stress-deformation functions obtained. After study of the strength properties, bone samples were dried, defatted, incinerated, and mineral composition (mineral saturation), composition of organic substance (by volume), and ratio of weight of the mineral component to weight of organic susbstance (mineralization coefficient) determined. Composition was determined using the atomic absorption spectral method (for calcium, magnesium, zinc), flame photometry (potassium, sodium), and spectrophotometry using ammonomolybdenic acid. Silicon was isolated using microdiffusion.

The mineral saturation of bone tissue in animals in the synchronous control group was somewhat elevated compared to those in the flight and vivarium groups, but no significant difference between the synchronous and flight groups was observed. Study of mechanical properties revealed a significant decrease in the limit of strength of bone tissue in the flight group, and a tendency for the limit of elasticity and limit function of elastic deformation to decrease in these animals. The magnititude of relative deformation determines the beginning of destruction of bone structures and may be considered as indicative of the state of bone substance. Relative deformation was significantly decreased in the space flight group relative to the other two groups. A negative correlation was found between relative deformation and concentration of phosphorus in the mineral component of bone ($r = -0.769$; $n = 15$).

The Ca concentration and Ca/P ratio in the mineral component were significantly depressed in flight animals. It is well known that amorphous

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octacalcium phosphate, which has a lower Ca/P ratio than hydroxyapatite, is precursor of the latter in the maturation of bone mineral. A decreased Ca/P ratio may indicate a relative decrease in the concentration of hydroxyapatite and accumulation of amorphous calcium phosphates in the mineral component. The concentration of silicon in the mineral component and the Si/P ratio were depressed in flight animals relative to the vivarium control, with intermediate values for the synchronous group. The concentration of magnesium was significantly depressed, while potassium, sodium, and zinc were significantly elevated in the flight group. A significant negative correlation was noted between concentration of sodium and Si/P.

On the basis of these results and data in the literature, we may hypothesize that decrease in the strength properties of bone tissue is linked to changes in the chemical composition of the mineral component. The reason for this may be decrease in the concentration of crystal oxyapatite and accumulation of amorphous calcium phosphates during physiological restructuring of the skeletons of pregnant rats exposed to weightlessness.

P645(15/88) Oganov VS, Skuratova SA, Rakhmanov AS, Magedov VS, Shirvinskaya MA, Shlyk GG.
Evaluation of the state of the skeletal muscles in monkeys under conditions of real and simulated weightlessness.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 287-288.

Musculoskeletal System, Skeletal Muscles, Electromagnetic Efficiency
Monkeys, Macaque-Rhesus
Space Flight, Cosmos-1514; Hypokinesia, Head-Down Tilt, Immobilization

Abstract: As a result of systematic studies on the Cosmos biosatellites, it has been established that reactions of skeletal muscles of rats to the absence of gravity is systemic in nature; however, the direction and extent of the changes observed are "individualized" in various muscles. In this study, we attempted to discover whether these principles applied to other species, particularly monkeys, and at the same time to determine the degree to which the effects of simulated weightlessness on the skeletal muscles of monkeys reproduce those of actual weightlessness.

To evaluate changes in the state of muscles in monkeys (macaque-rhesus) in space flight on biosatellite Cosmos-1514, we used the criterion of electromagnetic efficiency -- the magnitude of integral energy of the EMG, standardized for mechanical work. Muscle function was studied in monkeys which had undergone hypokinesia with head-down tilt (with limbs immobilized), by observing preparation of glycerinized muscle fibers contracting in a solution of $ATP+C^{2+}$.

The subject of the experiment on the biosatellite was a 3-year-old monkey taught to perform motor tests with electrodes implanted in the soleus muscle for registration of EMG. Physiological and other relevant information was recorded on magnetic tape. Integral energy of EMG standardized for mechanical work was calculated based on statistical processing of the values of the impulse strength in the active phase of motion and rounding procedures. The results of the analysis showed that electromechanical effectiveness of the muscles decreased during flight most sharply on days 1 and 5. Normalization began immediately postflight and was complete by approximately day 15.

The subjects of the experiment under simulated conditions were the extensor and flexor muscles of the calf and arm of monkeys after 7 days (2 animals) or 20 days (3 animals) of hypokinesia. Three control animals were used. Along with the decrease in muscle mass in the animals in the second group, we also noted a very clear decrease (compared to controls) in the strength of contraction of the fast twitch-fibers of the flexor muscles of the arm (humeral) and calves (long flexor muscle of the toes, tibia) and the fast twitch extensor muscle of the foot (gastrocnemius). The results of the study showed some difference in the reactions of these muscles in monkeys to the conditions of the experiment: horizontal or head-down tilt position with

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immobilization of the limbs. On the whole, the distribution of changes in various muscles studied agreed with the results of the study of the contractile properties of fibers of the same muscles in rats after space flight lasting 18-20 days. The dependence of reactions of muscles in one or another experimental situation on the nature of changes in functional demands made on individual muscles and on their biomechanical characteristics was confirmed.

Changes in the contractile properties of soleus muscle fibers in monkeys in response to weightlessness simulations agree in direction with results of dynamic evaluation of the state of this muscle in a 5-day space flight. We discuss possible reasons for the inflight decrease in the electromechanical effectiveness of the soleus muscle. These include: recruitment of additional motor units to perform the same motor task associated with a decrease in strength of contraction of individual fibers, changes in the mechanism for regulating movement and in the order in which motor units are activated, and decreased blood supply to the muscles.

P646(15/88) Pospishilova I, Pospishil M. (Czechoslovakia).
The effect of space flight on organic components of connective tissue.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 290-291.

Musculoskeletal System, Connective Tissue, Collagen
Rats, Female; Reproductive Biology, Pregnancy; Developmental Biology
Space Flight, Cosmos-1514, -1667

Abstract: The organic components of connective tissue, particularly collagen proteins, play an important role in supporting the functional and mechanical properties of bones and intercellular substances. From this point of view considerable importance is attached to the concentration of the so-called genetic types of collagen, the distribution of which may change as a function of various pathologic states. The goal of the present research was to study the possible effects of space flight factors on the organic components of connective tissue and to integrate the results of experiments performed on the Cosmos-1514 and -1667 biosatellites. We investigated the effects of 5-7 days of weightlessness on the distribution of types of soluble collagen in bone tissue of the femur and in subcutaneous tissue using the method of zonal precipitative chromatography, and also the ratio of collagen protein to concentration of glycoproteins.

The results of the experiments performed on the Cosmos-1514 biosatellite showed clear change in the components of connective tissue of the bone and subcutaneous tissue of pregnant rats exposed to weightlessness. This change involved decrease in type I collagen and increase in type III collagen. Changes in the distribution of various types of collagen were detected in the offspring of female rats flown on the biosatellite during their third trimester of pregnancy. These animals showed a tendency toward retarded bone development, as manifested by the immaturity of organic structure when they were mature. Their bones displayed a higher concentration of soluble collagen, a decrease in the ratio of collagen to glycoproteins, retardation in the accretion of type I collagen, and retention of types II and III collagen. There were deviations in the composition of connective tissue of the skin, as demonstrated by low levels of type I collagen and increased type III collagen during the early postnatal period.

The results obtained from the study of pregnant rats and their offspring were compared to results from analogous experiments on male rats exposed to weightlessness on Cosmos-1667. The likeliest reasons for the observed changes in connective tissue and the further possible pathologic consequences of these deviations were discussed.

P647(15/88) Savina YeA, Kaplanskiy AS, Durnova GN, Sakharova ZF, Plakhuta-Plakutina GI, Il'ina-Kakuyeva YeI, Prodan NG, Vorotnikova YeV, Alekseyev YeI.
Morphological manifestations of adaptive responses in rats exposed to tail suspension as a simulation of weightlessness.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 292-293.

Musculoskeletal Systems, Bone, Muscle; Endocrinology: Neurophysiology; Morphology
Rats, Male
Head-Down Tilt, Tail-suspension; Immobilization; Adaptation; Psychology, Stress

Abstract: It is commonly believed that hypokinesia with head-down tilt is the closest simulation of a number of effects of weightlessness. For this reason, an experimental simulation of weightlessness, proposed by YeI Il'in and VN Novikov, in which certain effects of weightlessness (fluid shifts, unloading of muckuloskeletal system) are simulated in rats by suspending them by the tail in a head-down tilt position is of considerable interest. In spite of the potential of suspension as a model for weightlessness, it has been used mainly for the study of biochemical changes or the state of individual systems. This paper describes an attempt to use morphological research methods to evaluate processes occurring in the major vital organs of rats during tail suspensions, and to compare these to the changes observed in horizontal hypokinesia.

Experiments were performed on male rats of the "Wistar" line weighing 180±5 g. Eight rats were suspended by the tail for 7 days, 10 rats spent the same period in horizontal position in immobilization cages, and 9 served as controls. Immediately upon completion of the treatment period all the animals were sacrificed and their brains, visceral organs, and certain muscles weighed. The brains, endocrine glands, visceral organs, and bones (tibia and lumbar vertebrae) were subjected to histological and morphometric analysis.

Weight measurement and histological analysis showed that 7 days of tail-suspension in rats is accompanied by shift of blood in the cranial direction and blood pooling in the visceral organs. Evaluation of the extent of stress reaction on the basis of organ weight and structure of the adrenal gland, thymus, and spleen showed that tail suspension does not affect the weight of these organs, nor do the adrenal cortex, thymus, or spleen show structural evidence of an acute stress response. At the same time activation of the medulla cells of the adrenal gland was noted.

In spite of the relatively brief duration of tail-suspension, it induced a pronounced restructuring of bone tissue, which testifies to inhibition of longitudinal bone growth and development of osteoporosis in the spongiosa of the tibial metaphysis and, to a lesser extent, the vertebrae. It

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should be emphasized that the diameter of the bone marrow canal and the width of cortical bone of the diaphysis of tibia bones did not change. No significant structural changes were noted in the endocrine glands participating in hormonal regulation of growth (somatotropes, adenohypophysis) and calcium metabolism (C-cells of the thyroid and parathyroid glands), although some activiation of the parathyrocytes occurred. Unlike the suspended rats, animals exposed to horizontal hypokinesia did not display redistribution and pooling of blood, nor were there pronounced signs of acute stress response, but structural changes in the bones and parathyroid were more pronounced.

Based on the material obtained in this experiment with tail suspension, we analyzed the extent of hemodynamic disruption in pulmonary circulation and of morphological manifestations of compensatory reactions in response to altered hemodynamics. We evaluated the tail suspension model from the standpoint of the symptoms induced by hypokinesia and the contribution of the stress component.

P650(15/88) Skuratov SA, Oganov VS, Shirvinskaya MA, Murashko LM, Silatsi T, Ser A, Papchak M.
The effect of short-term weightlessness on skeletal muscle functions in pregnant rats and their offspring.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 294-295.

Musculoskeletal System, Skeletal Muscle Functions
Rats, Female, Reproductive Biology, Pregnancy; Developmental Biology, Neonate
Space Flight, Short-term, Cosmos-1514

Abstract: It was previously established that 18- and 22-day space flights (Cosmos biosatellites) are accompanied by adaptive changes in the functional profile of the skeletal muscles. These changes differ across muscles and are most pronounced in the fibers of the postural muscles. In this work, which used data from a shorter duration flight, we expected to obtain a fuller description of the development of functional adaptation in different types of muscle, and elucidate the effect of the absence of gravity in the third trimester of intrauterine life on myogenesis and functional differentiation of rat muscles during the postnatal period.

On the day of biosatellite reentry, we isolated the skeletal muscles of the forelimbs -- medial head of the brachial triceps and the brachial muscle -- and also of the hindlimbs -- lateral and medial heads of the gastrocnemius, soleus, long extensor of the digits and the plantar muscle -- in three groups (flight, synchronous control, and vivarium control) of decapitated pregnant rats. The soleus and long extensor of the digits were isolated in normal living offspring, aged 15 and 30 days, of the same groups. Aside from weighing these muscles we studied their strength and contraction rate using preparations (fascicles) of glycerinized muscle fibers in a solution of $ATP+Ca^{2+}$.

The contractile force of muscle fibers was statistically significantly depressed in all muscles studied in animals of the flight group in comparison to the vivarium group. In terms of response to hypodynamia the muscle studied can be grouped as follows: fast twitch flexors (brachial, long extensor of the digits, and plantar), relatively fast postural (medial head of the gastrocnemius, medial head of the brachial triceps), somewhat slower (lateral head of the gastrocnemius) and slowest (soleus). The most significant effects were noted in fibers of the soleus, medial head of the brachial triceps and lateral head of the gastrocnemius, which resembled effects of hypodynamia simulations and 18-day space flight in male rats (Cosmos-936, and Cosmos-1129). The reactions of fibers in fast-twitch muscles are similar to the effects of laboratory hypokinesia (immobilization in cages). There was a tendency for rate of contraction in all the muscles studied to slow.

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Changes in the contractile properties of certain muscles (soleus, medial head of the brachial triceps, long extensor of the digits) in pregnant rats after a 5-day space flight were very similar (in direction and absolute value) to reactions of the same fibers in male rats after 7 days of hypodynamia (tail suspension). This allowed us to extrapolate data on the dynamics of the development of functional adaptation of muscles on longer space flights in male rats. There were no differences in contractile properties of muscle fibers of the soleus and long extensor in the offspring of the three groups of mothers. Dynamics of the development of speed and strength of muscle contraction in the period between days 15 and 30 in the lives of these animals also did not differ from the norm.

Thus, based on analysis of the results obtained we may conclude that at various stages of exposure to weightlessness (up to 1 week) adaptive hypodynamia of the postural muscles is evidently caused not only by atrophic processes, but by changes in central (neurogenic) and peripheral (muscle) regulatory mechanisms. Signs of functional adaptation revealed in fibers of postural muscles of rats exposed to a 5-day space flight result primarily from weightlessness, as after long-term flights. Changes in the functions of fast-twitch fibers are greater during this period than those occurring after long-term flights, showing the effects of contributing factors such as confinement in a small space. No convincing evidence was found that the absence of gravity during the third trimester of intrauterine development affects development of skeletal muscles during the period between days 15 and 30 of postnatal development.

P656(15/88) Stupakov GP, Kazeykin VS, Morozova NP.
Predicting the occurence of osteodystrophy in response to long-term weightlessness.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 364-366.

Musculoskeletal System, Osteodystrophy, Prediction, Personnel Selection; Mineral Saturation; Metabolism, Rate
Rats; Dogs; Humans, Cosmonauts
Space Flight, Long-Term, Cosmos-615, -782, -936, -1129, Salyut-6, -7 Weightlessness Simulations

Abstract: The increased duration of manned space flights, where an ecological factor as important as gravity is absent for long periods of time, leads to the development of osteodystrophy of the spongiosa of bones in the axial skeleton. At the same time, there is a decrease in strength and increase in the likelihood of trauma resulting from mechanical loading.

The urgency of the need to develop techniques to predict the severity of osteodystrophy is associated with the need to create methods for selecting crewmembers for long-term flights, to evaluate the efficacy of prophylactic measures for countering adverse effects of weightlessness on bone tissue, and to determine how much its tolerance of dynamic loading is reduced.

To develop an interspecies prediction method, we used existing data concerning changes in the mineral saturation of spongy bone structures of the axial skeleton in rats flown for 19 and 22 days on board Cosmos-615, -782, -936, and -1129 biosatellites, dogs which had undergone 90 and 345 days of simulated weightlessness, and results of experiments with subjects undergoing hypodynamia varying in duration.

Two principles revealed by these studies served as the basis of this technique: 1) mean monthly rate of development of osteodystrophy is inversely proportional to the initial concentration of minerals, i.e., baseline mineral saturation (MS, g/cm^3 in spongy bone tissue; 2) extent of osteodystrophy is directly proportional to rate/intensity of metabolic processes in the body as indicated by basal metabolism (BM, cal/day·kg).

Calculation of values for these parameters allowed us to predict mean monthly loss of mineral substances (V, %) using the following regression equation: $V = 0.128x-7.23$, where x is the ratio MB/MS.

The efficacy of this technique was verified by studying changes in mineral saturation of calcaneal bone in cosmonauts completing 140-, 175-, 185-, and 211-day flights on board Salyut-6 and -7, and subjects spending 30 to 120 days under condtions of hypokinesia with head-down tilt with or without use of various prophylactic countermeasures. The calcaneal bone was selected for study for the following reasons: 1) it is part of the axial skeleton and has a spongy structure; 2) its concentration of mineral

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substances correlates well with mineral concentration of the spine; 3) calculation of this correlational function, combined with certain other biological parameters, makes it possible to predict decrease in tolerance of dynamic loading; 4) it can be studied with a relatively portable device ("Bone Scanner" made by the "Studsvik" firm in Sweden).

Use of the predictive technique we developed showed it to be in good agreement with data from postflight examination. Based on the results obtained we drew the important conclusion that it is possible to select crewmembers for long-term flights who show a rate of osteoporosis 2-3 times lower than the group average. The desirability of basing selection on high levels of mineral saturation and low basal metabolism is evidenced by the fact that individuals with these characteristics show the greatest resistance to dynamic loading. Their rates of osteoporosis and decrease in resistance to mechanical forces are minimal. In addition, because they show only insignificant negative mineral balance (calcium, phosphorus, magnesisum), they are less likely to develop kidney stones.

Our results also showed some difference between predictions and real changes induced by the effects of mechanical prophylactic measures against adverse effects of weightlessness on bone tissue. However, to further decrease osteodystrophy, these measures must be improved and their use on spacecraft monitored more rigorously.

P664(15/88)* Kaplanskiy AS, Durnova GN, Sakharova ZF, Il'ina-Kakueva YeI.
Histomorphological analysis of the bones of rats flown on the Cosmos-1667 biosatellite.
Kosmicheskaya Biologiya i Aviakosmicheskay Meditsina.
21(5): 25-31; 1987.
[23 references; 11 in English]

Musculoskeletal System, Bone, Tibia, Iliac, Lumbar Vertebrae; Morphology, Histomorphological Analysis
Rats
Space Flight, Short-Term, Cosmos-1667

Abstract: This experiment studied the tibia, iliac, and lumbar vertebrae of 28 Wistar rats. The animals were divided into 4 equal groups: group 1 contained rats flown for 7 days on Cosmos-1667 and sacrificed 4-8 hours after reentry; group 2 was the vivarium control; group 3 was the synchronous control; and 4 was the vivarium control for the synchronous group. After being weighed, all animals were sacrificed. Bones were cleaned of muscles, fixed, decalcified, dehydrated, and longitudinal sections were prepared of the proximal section of the tibias and lumbar vertebrae, and the transverse section of the diaphysis of tibia and iliac bones. An optical microscope was used to measure the width of the chondral growth layer and the length of the trabecula of the primary spongiosa. Densities of the primary and secondary spongiosa were determined, and the number of haversian canals in the compact substance of the tibia counted. The outer and inner perimeters of the tibial diaphysis, the area of the cortical layer of the diaphysis in the marrow canal, and also the area of the haversian canals and osseous lacunae were measured using an image analyzer. Number of osteoblasts in the spongiosa of the lumbar vertebrae, iliac bones, and tibial metaphysis were counted in 25 (990X) microscope fields. Proportions of high, moderate, and low active forms of osteoblasts were computed for 500 cells. Number of osteoclasts in the vertebrae and iliac bones was counted in the primary spongiosa. Number of osteoclasts and active osteoclasts in the proximal metaphysis of the tibia was counted separately for growth layer and zone where primary spongiosa was being remodeled into secondary.

In spite of the short duration of the flight, clear signs of osteoporosis were noted visually in the spongy substance of the tibial metaphysis, confirming the measurable decrease in the density of the primary and secondary spongiosa and length of the trabeculae. The width of the epiphysial chondral growth layer did not change. These results reproduce data from a 18.5-day flight on Cosmos-782. In the tibia, number of osteoblasts decreased by 18%, as did the proportion of highly active forms. In addition, cells showing signs of dystrophic damage were present. Number of osteoclasts directly below the growth layer showed a tendency to increase, while those in the remodeling zone increased significantly. No changes were found in the tibial diaphysis of the flight group. Some osteoporosis was also noted in the synchronous group, but was not as extreme as for the flight group. Initial signs of osteoporosis were also found in the lumbar vertebrae of the flight group, but these were less pronounced than those in the tibia of the same animals. Number of osteoclasts in the vertebrae showed a tendency to decrease, evidently due to an increase in the width of the chondral growth layer, a change opposite to that occurring in the tibia. No changes were noted in the vertebrae of the synchronous group. Decreased growth layer width, trabecula length, and spongiosa density in the

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iliac bones of flight rats were not significant. However, decrease in total osteoblasts and highly active osteoblasts in the spongiosa of these bones was significant, while number of osteoclasts remained the same.

The authors conclude that development of osteoporosis in the bones of rats begins during the acute phase of adaptation to weightlessness, with clear signs occurring in the spongy substance of the tibial metaphysis. These effects are weaker in the other two bones studied. Differences in individual bones are attributed to differences in level of metabolism and functional loading. While signs of inhibited formation of new bone tissue were noted in all bones studied, evidence for intensified osteoclast resorption was found only in the tibia. It is not clear whether enhanced resorption does not occur at all in the other bones, or occurs only after longer exposure to weightlessness. The earliest signs of incipient osteoporosis are a decrease in the number of highly active osteoblasts and the appearance of dystrophic changes in cells of this type.

Table 1: Results of histomorphometric analysis of the metaphysis of tibial bones.

Parameter	**Group**			
	1	**2**	**3**	**4**
Width of growth layer, um	210	210	190	190
Length of trabecula of primary spongiosa, um	320*	460	360*	430
Density of primary spongiosa, %	44.3*	50.4	44.9	47.3
Density of secondary spongiosa, %	18.5*	28.8	23.9*	29.0
Osteoblasts:				
number in field	23.4*	28.3	19.2*	21.6
highly active, %	17.7*	29.7	16.7*	21.0
moderately active, %	70.3*	63.2	76.4	75.2
low active, %	11.9*	6.1	6.9	3.6
Osteoclasts beneath the growth layer:				
number in field	1.8	1.5	2.1	2.4
Osteoclasts in the remodeling zone:				
total number in field	2.3*	1.8	2.0	2.2
number of active cells in field	1.7*	1.2	1.4	1.4

* Here and in Tables 3 and 4 * designates statistically significant ($p<0.05$) difference between experimental and control conditions

Table 2: Results of the histomorphometric analysis of the tibial diaphysis

Parameter	**Group**			
	1	**2**	**3**	**4**
Outer perimeter of diaphysis, mm	12.3	12.0	12.8	12.7
Inner perimeter of diaphysis, mm	6.0	5.8	5.9	6.2
Area of cortical layer, mm^2	8.6	8.4	9.5	9.8
Area of marrow canal, mm^2	0.9	0.9	0.8	0.9
Number of haversian canals (per 20 squares of Stefanov grid)	87.4	93.8	89.3	92.6
Area of 1 haversian canal, um^2	136.3	161.7	167.3	176.8
Area of 1 osseous lacuna, um^2	43.8	40.3	47.6	53.4

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Table 3: Results of histomorphometric analysis of the lumbar vertebrae

Parameter	Group 1	2	3	4
Width of growth layer, um	145*	132	132	132
Length of trabecula of primary spongiosa, um	178	185	166	173
Density of primary spongiosa, %	58.2*	66.4	60.8	62.8
Density of secondary spongiosa, %	30.6*	34.7	34.0	30.8
Osteoblasts:				
number in field	15.1	16.2	14.1	12.9
highly active, %	7.7	11.4	7.1	6.5
moderately active, %	75.4	79.1	73.4	72.3
low active, %	16.9*	9.7	19.4	21.2
Osteoclasts in the zone of the primary spongiosa:				
number in field	2.0**	2.3	2.2	2.2

** Here and in Table 4, ** designates differences between experimental and control conditions, significant with $0.05 < p < 0.10$

Table 4: Results of histomorphometric analysis of the iliac bones

Parameter	Group 1	2	3	4
Width of growth layer, um	171	174	160	170
Length of trabecula of primary spongiosa, um	200	222	130	144
Density of primary spongiosa, %	42.8	45.6	35.2*	40.0
Density of secondary spongiosa, %	14.8	17.2	18.0	18.4
Osteoblasts:				
number in field	20.2**	27.0	14.4*	18.6
highly active, %	14.5**	21.0	6.9**	10.5
moderately active, %	75.0**	69.2	73.1*	81.5
low active, %	10.5	9.4	20.0*	8.1
Osteoclasts in the zone of the primary spongiosa:				
total number in field	2.9	3.1	3.4	3.7

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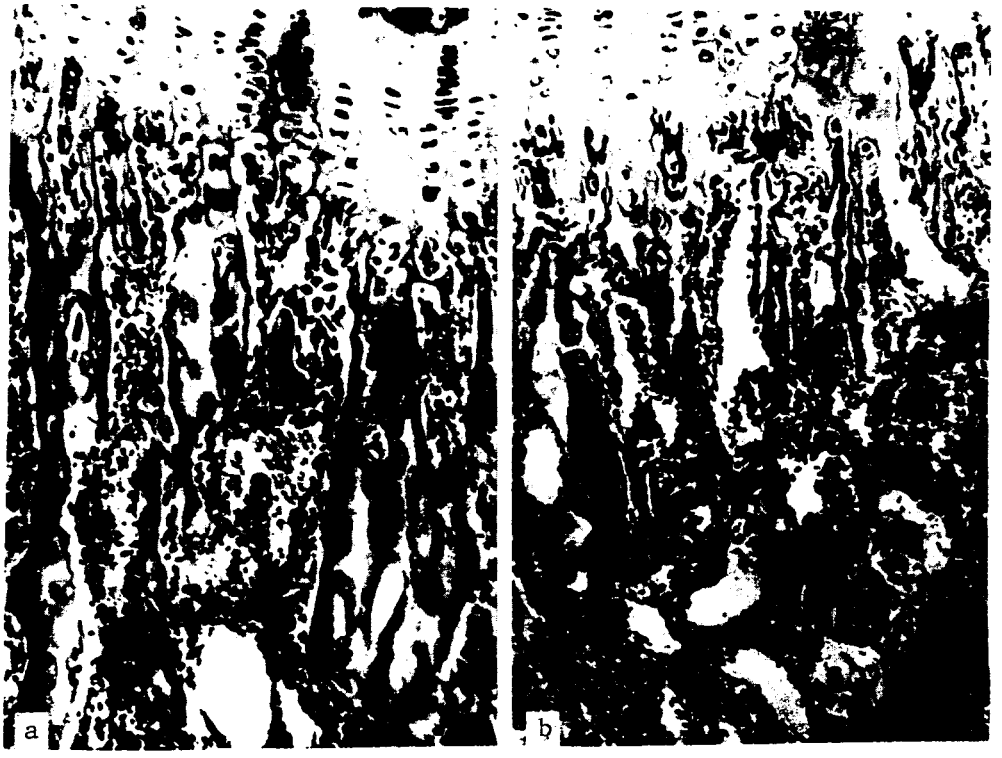

Figure: Osteoporosis in the tibia of rats after a 7-day flight on Cosmos-1667 biosatellite
a - spongy bone of the proximal metaphysis of the tibia in control rats; b - spongy substance of the proximal metaphysis of the tibia of rats spending 7 days on board the Cosmos-1667 biosatellite. Stained with picrofucsin. Mag. X 63

P676(15/88)* Mailyan ES, Burakova LB.
Preservation of muscles in the study of bioenergetic effects of hypokinesia.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 67-70; 1987.
[9 references; 2 in English]

Musculoskeletal System, Muscle Tissue, Preservation
Rats
Hypokinesia, Laboratory Technique, Low Temperature

Abstract: Under certain conditions muscle tissue from animals serving as subjects in weightlessness simulation experiments must be preserved for study. Traditional methods use freezing, but this involves some damage due to effects of crystallization of intra- and extracellular fluid. The authors propose a method involving low-temperature preservation of skeletal muscles at subzero temperatures with crytallization prevented by using glycerine (20% solution) as a cryoprotector. The method was tested 60 on outbred rats. The posterior femur muscles were isolated after decapitation, homogenized and immersed in a 20% solution of glycerine chilled to -5°C, where they remained for 30 minutes. They were then placed in a thermos containing small pieces of saccharose ice. The tissue remained in the thermos for 2-3 days at -7° - -1°C; under these conditions the glycerine solution does not freeze, muscle retains its color and shows no evidence of water crystallization in the tissue. After 2 days, the muscles were cleaned of the solution and subjected to differential centrifugation to isolate the mitochondria. Parameters of oxidative phosphorylation were measured using traditional methods. Respiration rate was measured in metabolic states 4p, 3, and 4o, as was phosphorylation time. Concentration of mitochondrial protein was measured as well. These parameters were compared to those of muscles measured immediately after isolation. It was found that the preservation process affected respiration rate (mean decrease of 35%) and arameters of oxidative phosphorylation (phosphorylation time increased by a factor of 1.5). In order to determine how important such decay in the muscle parameters is with respect to assessing the effects of hypokinesia, oxidative phosphorylation in muscles of animals subjected to 20 days of hypokinesia was compared for the two methods. Differences between parameters of the group exposed to hypokinesia and a control group were in the same direction when measured immediately after sacrifice and after preservation. In some cases, values of parameters were also the same. The pattern found from studying preserved muscle was identical to that discovered in muscles analyzed immediately. This leads the authors to conclude that when necessary this method of preservation may be used in postflight studies of muscles of animals exposed to space.

NEUROPHYSIOLOGY

(See also: Adaptation: P683; Developmental Biology: P683; Musculoskeletal System: P647; Psychology: P648)

PAPERS:

P630(15/88) Solodovnik FA.
Predicting incidence of motion sickness in cosmonauts during space flight.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 123-125.

Neurophysiology, Space Motion Sickness, Prediction
Humans, Cosmonauts, Individual Differences
Space Flight, Parabolic Flight

Abstract: Vestibular selection and vestibular conditioning do not always prevent incidence of space motion sickness in cosmonauts. It has been established that cosmonauts react differently to vestibular tests and actual space flight factors. For this reason, use of cosmonauts' tolerance of vestibulometric tests to predict susceptibility to space motion sickness is not fully satisfactory and does not provide sufficient help in planning work schedules during the initial days of space flight. A reasonable assumption is that the unreliability of prediction of the possibility of space motion sickness occurring in a particular cosmonaut during flight results from differences in susceptibility for different individuals to different specific vestibular stimuli. This property may also manifest itself in people showing satisfactory or high levels of vestibular tolerance, and thus it may be expected that even among cosmonauts, all of whom are tolerant, space motion sickness will occur during flight.

Analysis has shown that vestibular stimuli used in studies of vestibular tolerance of cosmonauts under laboratory conditions differ substantially from the vestibular stimuli encountered during space flight. Thus, Coriolus and linear acceleration occurring periodically and characterized by stimulation of the cupulo-endolymphatic system and otoliths play an extremely limited role [in space]. At the same time, motion sickness arising during space flight always occurs against a background of weightlessness. Consequently, vestibulometric tests used for predicting the likelihood of cosmonauts developing space motion sickness do not utilize stimuli similar in nature to those which give rise to motion sickness in space. These differences in vestibular stimuli make it difficult to reliably predict cosmonaut tolerance of space flight. To provide more accurate prediction, flight certification examinations should use vestibular stimuli closer in their qualitative characteristics to the stimuli giving rise to motion sickness in space.

The closest vestibular stimulus to the conditions of space flight is short-term weightlessness occurring during parabolic aircraft flight. However, cosmonauts report that motion sickness in space occurs mainly during motor

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activity, i.e., is during additional stimulation of the receptors in the vestibular system and other afferent systems in the context of ongoing weightlessness. The physiological effects of weightlessness on cosmonauts, combined with additional stimulation of receptors of various afferent systems, especially vestibular receptors, differ from the effects of weightlessness alone not only by virtue of the magnitude of the resulting compound stimulus but, more important, by virtue of the nature of receptor system stimulation. In order to increase the similarity of afferent receptor stimulation to that occurring in space, cosmonauts should be asked to follow a program involving active change in position in the cabin of a laboratory aircraft, including exposure to linear and angular acceleration during 10 periods of short-term weightlessness. During horizontal flight and acceleration, cosmonauts sit motionless, to minimize additional effects of these factors. The stimulation of afferent systems controlling spatial position is most similar here to factors giving rise to motion sickness during space flight. The occurrence of motion sickness during space flight can be predicted by evaluation of tolerance of short-term weightlessness accompanied by changes in position.

P653(15/88) Kovalev VYu, Enes AE.
Investigation of the postflight concentration of L-cystathionine in various areas of the brains of rats in an experiment on the Cosmos-1129 biosatellite.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 345-346.

Neurophysiology, Brain, L-Cystathionine, GABA
Rats
Space Flight, Cosmos 1129

Abstract: The amino acid L-cystathionine was discovered by Horvits (1947), who isolated this substance from mycelia of neurospores. L-cystathionine in the human brain was identified and measured by Tallan et al. (1958). The significance of this amino acid as a specific substrate of the brain is demonstrated by its concentration in the white substance of the brains of monkeys and humans, suggesting a possible association with metabolism in the axon membranes.

In space flight a set of factors affect human physiology and animals. Some of these may be modeled in ground-based experiments. Reproducing on the ground the psychological, emotional, and physical stress characteristic of the initial and final stages of space flight, leads to metabolic activation linked with the gamma-aminobutyric acid (GABA) system of the brain, which is expressed in a 2-3 fold increase in activity of glutamatdecarboxylase and GABA-transaminase. Along with GABA, glycine, homocarnosine and putreanine [sic., putrescine?], the physiological role of L-cystathionine involves participation in humoral regulation of inhibition processes in the central nervous system. Thus the study of concentration of L-cystathionine in various areas of the brain of rats during space flight is of undoubted interest for assessing certain aspects of the state of the central nervous system under exposure to space flight factors.

Rats of the Wistar-SPF line were used in an experiment on the Cosmos-1129 biosatellite. Concentration of L-cystathionine was measured using the method proposed by Shimits et al (1976). Analysis of variance was used to analyze the data.

Immediately postflight, concentration of L-cystathionine in the medulla oblongata of rats in the flight and synchronous group exceeded that of control rats by 34% and 10% respectively. No significant changes in concentration of this substance were noted in the cerebellum and cerebral hemispheres of either experimental group. In the hypothalamic area the concentration of L-cystathionine was elevated by factors of 2.2 and 1.5 in the flight and synchronous groups, respectively, compared to the vivarium control. The fact that there were no changes in concentration of L-cystathionine noted in the cerebellum or cerebral hemispheres suggests that exposure to extreme factors associated with space flight activated adaptive

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reactions which normalized L-cystathionine in these areas. Increased concentration of L-cystathionine in the medulla oblongata and hypothalamic area may be explained, on the one hand, by the fact that upon occurrence of the most pronounced stress the concentration of L-cystathionine may increase, since this compound is a mediator of inhibition and, on the other hand, the fact that during the development of adaptive processes myelinization of the neurons of the brain (in which L-cystathionine participates) increases.

P667(15/88)* Krylov YuV, Ivanov VV, Podshivalov AA, Zaritskiy VV.
On the role of optokinetic stimulation in vestibulospinal reflexes.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 36-41; 1987.
[14 references; 3 in English]

Neurophysiology, Vestibulospinal Reflexes
Humans
Optokinetic Stimulation, Step Test

Abstract: Experiments were performed on 23 volunteers aged 19 to 30. Effects of optokinetic stimulation of vestibulospinal reflexes were assessed by measuring angle of the body while the subject walked in place (step test) with eyes closed or during exposure to optokinetic stimulation. The step test required a rate of 100 steps per minute for 2 minutes; each session involved 4 tests separated by intervals of 3 minutes. For the first group of subjects (N=12) a session consisted of a test with eyes closed, tests accompanied by rightward followed by leftward optokinetic stimulation, and finally a test with eyes closed. The other group was treated identically except that leftward stimulation preceded rightward stimulation. The specially designed device for producting stimulation consisted of an optokinetic drum controlled by a motor attached to a helmet, a shield (blinders) for limiting uncontrolled visual stimulation, a device for illuminating the drum from within, and a power source. The drum was rotated at 60 degrees/sec. Optokinetic nystagmus (rate of slow phase) was measured starting 10 seconds before the step test with optokinetic stimulation and throughout the tests. The angle of inclination of the subject's body from initial position was recorded.

Rightward stimulation was associated with body inclination to the right in 19 subjects, to the left in 3, and no inclination in 1. Leftward stimulation results were exactly the reverse. Mean right inclination was 207^{o}, while mean left inclination was 406.4^{o}. Sequence of stimulation conditions had no effect on angle of inclination. During the stimulation condition of the step test, 30% of the subjects experienced counterrolling illusions. Optokinetic stimulation during the step test was associated with loss of balance in some subjects; this was 4 times as common when the stimulus rotated to the left. Slow phase nystagmic rate during optokinetic stimulation was reduced by performance of the step test; before and during the test left nystagmus was slower than right.

The authors conclude that optokinetic nystagmus reflects the functional capacity of the visual system to track objects moving in the field of vision. Since slow phase effects are correlated with angle of body inclination, it is argued that rate of the slow phase is a very useful criterion for identifying the effects of optokinetic stimulation on vestibulokinetic responses. Thus, optokinetic nystagumus is a promising parameter for use in assessing human statokinetic tolerance during multimodal stimulation.

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Figure 1: Optokinetic stimulation apparatus

Figure 2: Body inclination during step test

Figure 3: Functional diagram of mechanisms leading to body inclination during the step test

Figure 4: Mechanisms underlying stimulation of the visual system during optokinetic stimulation

P668(15/88)* Kondrachuk AV, Shipov AA, Sirenko SP.
Membrane model of the cupula of the semicircular canals of the vestibular system.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 41-47.
[24 references; 20 in English]

Neurophysiology, Cupula
Mathematical Modeling
Membrane Model

Abstract: The authors argue that in order to adequately reproduce the behavior of the cupula-endolymph system, one-dimensional models of cupula movement must be replaced by models which encompass its spatial structure; that is, models with focused parameters must be replaced by those with distributed parameters. A membrane model of the cupula provides a more adequate description of its behavior in response to acceleration than the traditional "swinging door" models. Existing membrane models are only applicable to a limited range of effects or fail to use distributed parameters. The authors' model assumes that the semicricular canal is a torus filled with homogeneous, viscous, noncompressible liquid (endolymph) of a certain density. A cross section of the torus is covered by a membrane (cupula) of given thickness; the density of the membrane substance and the liquid in the canal are the same. Taking actual parameters of the semicircular canal into account, it can be concluded that during physiological movement, the flow of liquid in the canal is laminar. It is also assumed that the presence of the membrane covering a cross section of the canal does not disrupt the laminarity of the flow. Responses of the model to a stop-stimulus and periodic stimulation are considered. The authors emphasize that the given model corresponds to the functional behavior of the cupula and is not supposed to be a description of its actual form. They argue that experiments which identify the elasticity and surface properties of the cupula are needed to assess the adequacy of the membrane model.

P674(15/88)* Simonov LG, Tsaturyan AK, Saribekyan AS, Shmidt LG.
Assessing "reserve spaces" in the cerebrospinal system using noninvasive measures.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 62-65; 1987.
[10 references; 3 in English]

Neurophysiology, Cerebrospinal System
Humans, Patients
Reserve Spaces, Noninvasive Measures, Ultrasound

Abstract: The relationship between volume and pressure in the cerebrospinal system has important clinical diagnostic and prognostic significance. Data obtained in research and clinical practice has led to the concept of "reserve spaces" which may be studied with noninvasive methods. This work used ultrasound echoencephaloplethysmography recorded in a variety of body positions to evaluate this concept. Subjects were 15 patients with circulatory disorders of the brain or skull or brain injuries, and also 30 healthy individuals. In 6 patients intracranial pressure was measured using ventricular drainage or a subdural balloon which had been introduced for therapeutic reasons. All subjects were examined using echoencephaloplethysmography. A frontooccipital lead was used to receive the signal from the occipital bone, changes in which were considered to reflect changes in the lateral ventricle of the brain. Subjects were placed on a tilt table which was used to create continuous shift in orientation of the head and trunk with respect to the horizontal, within the limits of $\pm 15^{0}$. Maximum negative angle for patients was -6^{0}.

Invasive methods showed that change in intracranial pressure in the neurosurgical patients during tilt tests was a linear function of angle of inclination of the subject's body (β^{0}). The correlation coefficient was 0.93. Length of the lumbar canal had an effect on this association. The regression equation derived ($\Delta P = 6.8\beta + 6.68$) holds for lengths between 500 and 700 mm.) During tilt tests on the 6 patients, intracranial pressure was measured invasively and change in volume was measured with ultrasound. A nonlinear association was found. A modulus of elasticity was derived by dividing increase in pressure by increase in echo signal. When this modulus is plotted as a function of pressure, the curve has two segments, one of which is horizontal and the other oblique with a point of inflection at approximately P = 195 mm Hg. When only noninvasive methods are possible, β can be substituted for P in determining E. The noninvasive P-V function obtained using a tilt test has diagnostic value since it reflects the state of intracranial volumes. The portion of the curve where modulus of elasticity is unchanged while angle of inclination of the body increases suggests the presence of "reserve spaces" in the cerebrospinal system and is called the "region of optimal pressure." In subjects with neurological disease the region of optimal pressure was computed to occur at an angle of approximately $+10^{0}$, while the inflection point occurred at negative angles of body inclination in healthy subjects.

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Figure 1: Pressure in the cerebrospinal system as a function of angle of inclination of a tilt table for subjects as a whole and short and tall subjects

Figure 2: Changes in pressure and an indicator of volume when body inclination is changed relative to the horizontal

Figure 3: Elasticity as a function of invasively measured pressure and body inclination

NUTRITION

(See also: Life Support Systems: P635; Metabolism: P654)

PAPER:

P637(15/88) Bychkov VP, Kalandarov S, Kochetkova AN, Sedova YeA, Ushakov AS, Frumkin ML.
Diet of cosmonauts of the three Salyut-7 prime crews.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages 220-221.

Nutrition, Cosmonaut Rations
Humans, Cosmonauts
Space Flight, Salyut-7, Life Support Systems

Abstract: The most satisfactory cosmonaut nutritional system on Soviet manned space flights was the one developed for Salyut-7. It included cosmonaut rations, containers for serving and storing food, a dining table, an electric food heater, utensils and dishes, devices for regeneratiing water and measuring and adding hot and cold water to packages of freeze-dried food, containers for disposing of waste, and a refrigerator for storing fruit and vegetables. The diet of Salyut-6 crews consisted of approximately 80% canned, sterilized food, and only 20% freeze-dried foods. All the cosmonauts noted that they became tired of the sterilized, canned food by the end of month 2 of flight. For this reason, rations were developed for the Salyut-7 crews which had equivalent food value, but consisted primarily (65%) of freeze-dried products, rehydrated with hot or cold water, which were less likely to become monotonous. The rations of the Salyut-7 crews had a caloric value of 3150 calories and were well balanced, containing all the nutritional requirements, as demonstrated by ground-based simulation studies and flights of Salyut-6 crews.

During the flights of the three Salyut-7 prime crews, all components of the nutritional system functioned normally, supporting crewmembers' work capacity to the extent needed to fulfill the flight mission. The crews reported that the taste of the food did not change during the flight. No dyspeptic disorders were noted and evacuation was regular. Some comments made concerning the taste of some of the food will be taken into account in further efforts to improve cosmonaut rations.

A new system for organizing foods was introduced on Salyut-7. Each product had its own container and number. The new system allowed an accurate record of the quantity of food used, and made it possible to design meals on the basis of individual tastes.

OPERATIONAL MEDICINE

(See also: Microbiology: P638; Cardiovascular and Respiratory Systems: P673)

PAPERS:

P622(15/88) Anashkin OD, Andretsov VA, Bernadskiy VI, Bogdanov VI, Volgin VA, Demida BF, Kaniovskiy SS, Monastyrev AA, Pozdnyakov SV, Ponomarev SI, Talavrinov VA, Chirkov AA.
Operational control of medical support during flights of "Salyut-7" visiting crews.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages 5-6.

Operational Medicine, Medical Support
Cosmonauts
Space Flight, Salyut-7, Visiting Crews

Abstract: The main goal of operational medical support is maintenance of cosmonauts' health and support of their physical and psychological work capacity at a level that ensures successful performance of the flight mission. This goal is achieved through collection and analysis of data on crewmembers' health, work and rest schedule, nutrition, water usage, prophylactic countermeasures, and by monitoring the major parameters of gas composition of the atmosphere and sanitary/hygienic condition of the spacecraft cabin. Medical support involves derivation and implementation of medical recommendations directed at improving the health and work capacity of the cosmonauts in flight. Cosmonauts' health is monitored using telemetric data concerning the results of medical monitoring and microclimate parameters, cosmonauts own reports on their well-being, visual observations during television transmissions, and results of analysis of radiocommunications.

The present work presents the results of medical monitoring of the health of members of 4 visiting crews on board the "Salyut-7" station, on missions lasting 7-12 days. The cosmonuats felt well throughout the flight. During the initial period they noted moderate shifting of blood to the head, which did not affect their work capacity. The cosmonauts reported fatigue which developed at the end of a day and was corrected by sleep.

On these flights, 5-6 people were using the space station, and this required careful monitoring of compliance with all aspects of the work and rest schedules. Physiological parameters of all 12 cosmonauts were appropriate to the various stages of the flight. Heart rate during the prelaunch period increased on the average from 60 to 80 beats/min, reaching a maximum value of 88 beats/minute during the active portion [of the launch], and averaged 68 beats/minute during orbital flight. The temporal and amplitude characteristics of the EKG did not exceed the norm and were appropriate to heart rate. The visiting crews typically showed strong motivation to complete all their tasks well and thoroughly, enthusiasm, and stable

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interest and goal structures. On the whole, the medical support system facilitated maintenance of crew health, and support of physical and psychological work capacity at all stages of the flight.

PERCEPTION: See Adaptation: P683
PERSONNEL SELECTION: See Musculoskeletal System: P656

PSYCHOLOGY

(See also: Cardiovascular and Respiratory Systems: P628; Musculoskeletal System: P647; Human Performance: All; Space Biology and Medicine: M118)

PAPERS:

P633(15/88) Polevoy LG.
GABA derivatives: Types of effects and methods of evaluation with respect to the goals and requirements of space psychopharmacology.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages: 195-196.

Psychology, Space Psychopharmacology, GABA Derivatives
Humans, Cosmonauts
Adaptation, Space Flight Factors

Abstract: Goals of this research area are: search for pharmacological means of optimizing operator performance in man-machine systems in order to maintain an adequate level of work capacity during exposure to extreme factors; development of medicinal methods for prevention of psychogenic disturbances and, in particular, information-processing neuroses when the risk of occurence is high; and experimental evaluation of the efficacy and safety of use of drugs by operators while performing their jobs, which may be referred to as "engineering psychopharmacology." The branch of this area concerned with the solution of these problems with respect to space flight conditions can then be called "space psychopharmacology." This area of research is important for space medicine because space flight factors are, to varying degrees, risk factors for occurrence of psychogenic disturbances, which may negatively influence physiological resistance and decrease work capacity.

For these reasons, we studied a broad range of drugs from different pharmacological groups, including tranquilizers, neuroleptics, soporifics, narcotic and nonnarcotic analgesics, antihistamines, spasmolitics, myorelaxants, anti-motion sickness drugs, cardiotropics, antidepressants, psychological stimulants, and nootropic drugs. Special attention was paid to drugs with polymodal effects, combining the various types of neuro- and psychopharmacological activity with nootropic characteristics.

The majority of nootropic substances currently known are derivatives of GABA. They are used clinically in disturbances of consciousness, memory, intellect, and in healthy individuals may be used like adaptogens with the goal of expanding adaptive capacity. The major effect of these drugs is associated with metabolic level and has antihypoxic, ergotropic, neurostabilizing and antitoxic properties, which, in combination with various neuro- and psychotropic, effects determine the qualitative direction

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of adaptogenic effects.

When an individual is exposed to a set of extreme factors and must continue to perform job tasks, the use of GABA derivatives to normalize functional state is rational and justifiable. In such a case, drugs with polymodal effects may play the role of a "pharmacological damper," stabilizing and synchronizing biorhythms, attenuating functional shifts and creating the reserve time needed for adaptive restructuring, preventing the most extreme stresses on adaptive mechanisms which may lead to their exhaustion. At the same time, this drug must have no negative effects on job skills and performance capacity.

With this in mind, we investigated the various types of effects of GABA derivatives and their significance in faciliating adaptation, performed a comparative evaluation of these effects on the functional state of operators under conditions simulating space flight factors and on their job performance. We used graphic and mathematical methods of analysis to identify different types of functional state which develop under exposure to extreme factors and found that when operators are adapting to a complex information-rich environment shifts from one state to the next occur in a quantum fashion. The capacity of GABA derivatives to increase physiological tolerance of a broad range of factors, including hypoxia, orthostatic and statokinetic loadings, disruption of the "sleep-waking" cycle, cognitive overload and emotional stress was also demonstrated.

Phenibut (gamma-amino-beta-phenylbutyric acid hydrochloride) displayed a broad range of effects which combined with its neurostabilizing, statoprotector, tranquilizing, euhypnotic and psychoactivating effects. This drug was used to demonstrate that the neuro- and psychotropic effects arising as a result of one time use of GABA derivatives with polymodal effects may facilitate short-term adaptation to extreme factors, while the effects occurring with repeated use may facilitate long-term adaptation, encouraging a shift to a higher level of resistance to environmental factors and living conditions.

P648(15/88) Shlyk GG, Korol'kov VI, Kozlovskaya IB, Shirvinskaya MA, Efimova MYa, Peshekhonov OF, Abramov ON, Polyakov VV.
Use of parameters of instrumental reflexes to assess the adaptive capacities of the higher nervous system in monkeys on Cosmos biosatellites.
In: Gazenko OG (editor).
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**]. See CR7, this Digest issue.
Moscow: Nauka; 1986.
See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.
Pages:303-304.

Adaptation, Space Flight, Cosmos; Neurophysiology, Higher Nervous System
Primates, Monkeys
Psychology, Learned Instrumental Reflexes; Stress

Abstract: Instrumental reflexes are used to assess higher nervous activity in humans and animals and are one of the parameters of functional state during exposure to extreme environmental factors. This proposition formed the basis of research on Cosmos series biosatellites. Complex conditioned responses were developed using food as reinforcement in 2 training programs using specially developed conditioning algorithms on a set of computer-controlled training devices.

In the first training program positive and distractor signals were presented to the animal on a semicircular panel in a random left-right sequence. Correct response, squeezing of a manual actograph within a given period after presentation of the positive stimulus, was reinforced with juice; errors - pressing in response to the distractor stimulus or failing to press in response to the positive one -- were punished by delaying presentation of the next conditioned stimulus. In the second training program, food reinforcement was associated with performance of a movement consisting of pressing a pedal actograph three times with a given amplitude, followed by tonic holding of the pedal in a specific zone for 1-2 seconds.

We studied the state of higher nervous activity in monkeys exposed to a number of factors, accompanying the pre- and postflight experiments (immobilization, isolation, noise, acceleration, transport to another city, etc.). Short term exposure to even the more intense stimuli (revolution on a centrifuge, noise, and others) followed by testing of the conditioned reflex in surroundings familiar to the animal, did not, as a rule, lead to pronounced inhibition of the conditioned reflex. When inhibition did occur, its duration did not exceed 3 days. At the same time, changes in the experimental situation in transporting the animals, rigid immobilization and isolation (placement in the Bios-Primat capsule, in the biosatellite or its ground-based mock-up) were accompanied by longer and more pronounced disruption of higher nervous activity (up to 6 days and more).

Analysis of the experimental material showed that the instrumental reflexes developed in the second program were more sensitive indicators of monkeys' functional state. Disruptions of these reflexes were much more frequent and lasted far longer. Restoration of a monkey's functional state after exposure to one of the disturbing factors required repetition of

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the training process. The state of the higher nervous system of monkeys determined on the basis of instrumental reflex parameters was one of the most important criteria for selecting animals and predicting their endurance of space flight. The results of the studies revealed significant differences in the stability of instrumental reflexes developed in the first and second training programs in the face of the factors utilized. The correlation discovered between stability of conditioned reflex activity and adaptive capacities of the central nervous system of monkeys made it possible to quantitatively evaluate their psychological adaptability and more accurately monitor the functional states of the animals in ground-based experiments and flight.

P677(15/88)* Savchenko NYa.
The immediate and remote effects of nonlethal irradiation with accelerated high energy helium ions on maintenance of existing [learned] behavioral patterns [responses] and formation of new ones.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 70-72; 1987.
[9 references; 1 in English]

Psychology, Learned Behavior Patterns, Maze, Stress
Rat,
Radiobiology, Accelerated High Energy Helium

Abstract: Experiments were performed on adult male Wistar rats. A maze was used to develop a chain of conditioned motor reflexes. To further complicate the performance requirement, stress was introduced in the form of a 3000 Hz sound for 20 seconds before beginning of the trial, and the difficulty of the maze was increased. Rats were trained in the apparatus until they were able to perform 100% correctly on 3 consecutive trials. Parameters measured included: latency, number of total failures, duration of the locomotor reaction, total time, and mean number of errors. Motor activity was measured as the length of the path traversed within the maze. The rats underwent whole body irradiation with accelerated helium ions with energy of 4HeV/nuclons in a dose of 5.0 Gy. Dose rate was 0.0003 Gy/sec. A control group was subjected to placebo radiation. Each group contained 8 rats, trained in the response before the beginning of the experiment. Maze performance was tested 6 and 24 hours, 5 - 7, 10, 20 and 30 days, and 1.5, 3, and 6 months after the treatment.

Six and 24 hours after irradiation, performance on the maze was significantly worsened. After 5-7 days number of errors and latency decreased. Introduction of the high frequency sound led to marked disruption of the response with considerable inhibition of the response at noise onset and effects on motor activity after offset. Number of errors increased and ratio of errors on trial 3 to those on trial 1 increased by a factor of 2.7 compared to the control. Requirement to run 16 trials, rather than 3, in a session on day 20 after irradiation led to an increase in latency and total time to run the maze, and also to increased motor activity, percent of errors, and overall retention of the response. Thus, irradiation with accelerated high energy helium ions led to a number of phases of effects on a learned response. The first phase involved inhibition of the reflex during the first few days after irradiation. Restoration of a number of parameters occurring during the first week suggested the development of compensatory processes. However, continued elevation in the latent period, total time to perform tasks, and total errors indicate functional weakness of cortical processes. Depression of the response accompanied by increased excitability in response to introduction of a sound stimulus, suggests pathological lability and prevalence of the stimulation process. Increasing task complexity led to some decrease in work capacity. However, recovery of the disrupted functions was noted during later testing.

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Table: Behavioral response in rats in a maze 6 hours after irradiation with high-energy accelerated helium ions in a dose of 5.0 Gy

Parameter	Irradiated Group	Control Group
Motor activity, number of maze sections	59.5	58.6
Mean number of errors	11.4**	5.4
Disruption of the habit, %*	162.5**	30.2
Latency, seconds	10.8	11.5
Total time to perform maze, seconds	304.5	129.7
Feeding activity, %	83.3	97.8

* Relationship between errors on trial 3 and errors on trial 1
** $p < 0.05$.

Figure 1: Retention of old and acquisition of new behavioral habits in rats after exposure to accelerated ions at a dose of 5.0 Gy.

Figure 2: Motor activity of rats on day 20 after irradiation with high energy helium in a dose of 5.0 Gy when task demands are increased

P681(15/88)* Durnova GN, Vorotnikova YeV, Prodan NG.
Comparisons of stress reaction in rats exposed to different simulations of certain effects of weightlessness.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 79-81.
[7 references; 6 in English]

Psychology, Stress Response; Endocrinology, Adrenal, Thymus
Rats, Male
Weightlessness Simulations, Immobilization, Tail Suspension

Abstract: A total of 38 male Wistar rats served as subjects in this experiment. Of these, 10 were sacrificed immediately (1), 10 were housed in immobilization cages for 7 days (2), 8 were placed in tail-suspension devices for 7 days (3), and 10 were housed in a vivarium for the same period (4). After the 7-day experimental period, all remaining animals were sacrificed and their adrenal and thymus glands, and spleens were removed and weighed. Lipid concentration in the adrenal glands was determined. Samples of the thymus and spleen were cut into cross sections.

Animals in groups 3 and 4 continued to grow, while animals in group 2 lost weight compared to the group 1. The weight of the thymus, adrenal glands, and spleens of tail-suspended rats (group 3) did not differ from that of the vivarium control (4); thymus and spleens of immobilized rats decreased in weight; weight of adrenal glands remained constant in absolute terms and thus increased in relative terms. Histochemical analysis of the lipid content of the adrenal glands of group 2 rats showed absence of normal concentration of lipids in the gland, differences in staining properties, and loss of boundaries between various zones. No such differences were found in group 3 animals, but they did show a large number of small drops of lipids and no sudaphobic zone. Such changes are characteristic of recovery after stress. All animals in Group 2 and 2/8 in group 3 displayed involution of the thymus. The spleens of group 3 animals did not differ from those of group 4 animals, with the exception of some increase in hemosiderin. Immobilization was associated with hypoplasia of the white splenic pulp, as demonstrated by decreases in size of lymphoid follicles and number and size of their white centers. Group 2 animals also showed increased concentration of hemosiderin. Results are interpreted as demonstrating that immobilization engenders an acute stress response lasting for 7 days. Tail suspension leads to only a moderate and relatively short-lived response which dissipates by the end of the 7-day period. The authors conclude that tail suspension is a better simulation of weightlessness for use in ground experiments.

Table: Effects of 7-day exposure to immobilization and tail supension on body weight, and weight of thymus and adrenal glands and spleens of rats

RADIOBIOLOGY

(See also: Botany: P643, P651, P649; Exobiology: P652; Psychology: P677)

PAPER:

P682(15/88)* Zubkova IV, Gutorova LV, Panferova NYe.
The effects of hypokinesia with head-down tilt and illumination conditions on sensitivity of skin of the upper body to UV-radiation.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(5): 81-82; 1987.
[4 references; 3 in English]

Radiobiology, UV Radiation, Skin Sensitivity
Humans, Males
Hypokinesia with Head-Down Tilt, Illumination

Abstract: A total of 27 males, aged 35-40, participated in this experiment. Group 1 (n=19) subjects participated in two conditions. In the first, the effects of a 2-hour period of hypokinesia with head-down tilt (-12^{o}) on sensitivity of skin of the chest, stomach, back, and inner surface of the forearm to ultraviolet radiation were investigated. In the second condition the effects of exposing the skin to ultraviolet radiation combined with daylight [apparently with and without head-down tilt] on UV sensitivity were studied. The second group of subjects participated in experiments to determine the effect of changing from a seated position to head-down tilt on UV sensitivity of skin of the chest, stomach, and back. For irradiation, the authors used a 6-lamp luminescent UV-radiation source for which radiation density in the UV-C, UV-B, and UV-A regions was 0.035, 1.6, and 0.8 W/m^2, respectively. Skin sensitivity was measured using a biodosimeter. The minimal erythemal dose was identified with the smallest amount of UV radiation causing reddening of the skin. Short periods of hypokinesia with head-down tilt were found to be associated with increased sensitivity to UV radiation. Addition of daylight further increased sensitivity. Moving from sitting to head-down position also increased skin sensitivity.

Table: Minimum erythemal dose for various areas of the skin as a function of body position and illumination conditions

REPRODUCTIVE BIOLOGY: See Developmental Biology: P644, P663; Genetics: P655; Musculoskeletal System: P642, P646, P650)

SPACE BIOLOGY AND MEDICINE

MONOGRAPH:

M118(15/88) Gazenko OG, Pestov ID, Makarov VI.
Chelovechestvo i Kosmos [**Humanity and Space**].
Mosocw: Nauka; 1987.
[272 pages; 28 illustrations; 4 pages of references]
Affiliation (book): USSR Academy of Sciences.

Key Words: Space Biology and Medicine, Human Performance, Psychology, Space Flight Research, Biospherics

ANNOTATION: This book discusses the stages, milestones, rate, and trends in the development of cosmonautics. Much attention is devoted to the biomedical aspects of the conquest of space. The major conclusions of medical, biological, and engineering psychological research performed on space flights are cited. Effects of a substantial proportion of the population living in space colonies on the biological evolution of man are predicted. An overview is given of the possible ways in which space will be colonized. Transformations of nature, economics, and social relationships attributable to the conquest of space are evaluated. The significant role to be played by cosmonautics the solution of current global problems is discussed.

CONTENTS

(Numbers in parentheses refer to page number in original.)

CONFERENCE REVIEW:

CR8(15/88)* Salivon SG.
Second All-Union Conference on "Physiology of extreme states and individual protection."
In: Kosmicheskaya Biologiy i Aviakosmicheskaya Meditsina.
21(5): 86-89; 1987.

Key Words: Space Biology, Space Medicine, Adaptation, Extreme Conditions, High Altitude, Decompression Sickness, Acceleration, Psychology, Stress, Human Performance, Individual Differences, Biofeedback, Pharmacological Countermeasures, Physical Exercise, Weightlessness Simulations, Hypokinesia, Immersion, Toxic Factors, Cosmonaut Training, Equipment and Instrumentation, Operational Medicine, Immunology, Endocrinology, Metabolism

The need for humans to perform work under extreme and/or adverse conditions is a pressing issue which today merits the attention not only of industrial hygienists and physiologists, but also psychologists, sociologists, industrial designers, and representatives of many clinical disciplines. This fact was reflected in the range and variety of topics addressed at the Second All-Union Conference on "Physiology of extreme states and individual protection of human beings" and demonstrates the level of attention devoted to such problems in institutes of the USSR Academy of Sciences, USSR Academy of Medicine, Ministry of Health Institutions, All-Union Central Council of Professional Associations, and the specialized laboratories of the other departments and higher educational institutions of the country.

The leading scientists of the nation and associates of 65 organizations of various ministries and departments participated in the conference, which was organized by the USSR Ministry of Health and the Institute of Biophysics of the USSR Ministry of Health.

The major problems presented for discussion at the conference concerned the effects of adverse environmental temperature, altered barometric pressure, and toxic factors. Psychophysiological problems of human performance in extreme conditions, means to compensate for and restore functional state under exposure to extreme factors, and questions of protecting the individual and automating scientific research were also considered.

Cosmonaut V.A. Dzhanibekov, twice Hero of the Soviet Union, greeted the delegates in the name of the Yu.A. Gagarin Cosmonaut Training Center. He emphasized that issues considered at this conference encompass not only the traditional "terrestrial professions," but also those of pilot and cosmonaut. The entire system of training and special conditioning of pilots and cosmonauts is based on scientific developments, which take into account the physiological effects of unusual space flight factors, stress situations, and contingency and emergency situations.

V.A. Dzhanibekov expressed the hope that specialists in the physiology of extreme states will continue their research such important areas as the effects of weightlessness on the body and search for measures to protect humans from the adverse effects of this factor, development of measures to maintain physical and mental work capacity during space flight and improve methods for hastening the recovery of cosmonauts after reentry.

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D.I. Shparo, director of the Polar Expedition sponsored by the newspaper "Komsomolskaya Pravda," presented the major results of multiyear biomedical research performed jointly with the Institute of Biophysics of the USSR Ministry of Health and the Institute of Clinical and Experimental Medicine of the Siberian Division of the USSR Academy of Medicine. Special attention was devoted to analysis of the psychophysiological states of expedition members under conditions of multiday excursions including those during polar night, and the development of strategies and tactics for medical support of such trips. The need to create an individual protection system for people working autonomously at high latitudes was noted. D.I. Shparo then focused on the training of teams to take ski trips to the South Pole and asked specialists in extreme physiology and individual protection to take an active role in biomedical research programs.

A paper by Professor F.B. Berezin (Sechenov Medical Institute, Moscow) was devoted to emotional stress, personality traits and protective mechanisms. Detailed consideration was given to the mechanisms underlying psychological adaptation. The author identified 3 closely interrelated aspects of psychological adaptation: purely psychological, social-psychological, and psychophysiological. This classification is based on a multifactor investigation of psychological diagnostic parameters, level of cerebral activity, autonomic humoral regulation, and other data characterizing the activation of physiological functions in the process of job performance. The multicomponent structure of psychological adaptation in many respects affects the nature of the stress reaction of emotional tension and neuroautonomic stability in individuals, on their health, and job performance.

A paper by academician A.V.Val'dman (Institute of Pharmacology, USSR Academy of Medicine) considered pressing problems in pharmacological compensation for extreme states. The initial phase of development of any extreme state is emotional stress. The author cited data on mechanisms underlying the actions of a heterogeneous class of neuro- and psychotropic drugs, their effects on the development of behavioral, physiological, and biochemical components of emotional stress, discussed the role of emotional stress in the development of specific physiological changes occurring under exposure to various environmental factors, underlined the role of individual and typological differences in physiological reactions to the effects of the stress factor and drugs. In the opinion of Professor N.N. Vasilevskiy (Institute of Clinical and Experimental Medicine, USSR Academy of Medicine) parameters indicative of flexibility, stability, and interrelationships of physiological processes must form the basis for diagnosing individual and typological differences, for predicting adaptation under extreme conditions and correcting maladaptive disturbances. These parameters were tested using biological feedback measures. Groups of individuals were identified with low, medium, and high adaptivity. Based on these feedback methods, the author developed techniques for correcting maladaptative disorders by training directed at developing stability of biorhythm functions and coordination among physiological systems.

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Medical doctor V.G. Volovich (Institute of Biomedical Problems) focused on complex problems related to survival of individuals alone in uninhabited regions in the North, tayga, desert regions, and seas and oceans. The author emphasized that individuals who find themselves in such areas (as a result of accidents, natural catastrophes, or for other reasons), often die not from the effects of extreme factors themselves, but from lack of appropriate knowledge and skills, from failure of the will to struggle for survival, and the absence of equipment and means of protection.

In the author's opinion, practical detailed instruction is essential to everyone who is likely to find himself outside of the civilized area of cities in severe natural conditions unfamiliar to the overwhelming majority of the population, who tend to overestimate their survival skills.

The work of the section devoted to extreme factors in aviation and cosmonautics concentrated on three major areas: research on the physiological effects of high altitude factors, particularly high-altitude decompression sickness in humans; long-term exposure to acceleration and associated means of protection; and effects of simulated weightlessness on various physiological functions, particularly in older individuals.

The report by V.I. Chadov and L.R. Iseyev (Institute of Biophysics, USSR Ministry of Health), devoted to the dependence of maximum acceptable coefficient of saturation (MACS) on magnitude of postdecompression pressure, was of particular interest. Based on a large body of experimental material, the authors established safe decompression schedules, which for altitudes ranging from 6100-9300 virtually correspond to a MACS, equal to 1.63, further increase of altitude to 10,800 leads to a decrease in this coefficient. New data were presented by L.G. Golovkin et al., in a paper concerned with the use of the principle of redistribution of blood in the design of high-altitude gear and in a report by V.P. Katuntsev (Institute of Biomedical Problems) on "Ultrasonic recording of gas bubbles and the appearance of symptoms of decompression sickness in ascending to high altitude." Yu. S. Ilyushin, A.S. Yarov, V.S. Yakovlenko (Institute of Biophysics) demonstrated that the use of one-way stretch fabric in high altitude suits provides high mobility working comfort, in spite of excess pressure.

A series of reports devoted to simulating weightlessness stressed prevention of functional disorders, particularly through physical training. These recommendations were summarized in a paper by V.I. Stepantsova and I.B. Koslovskiy (Institute of Biomedical Problems). The authors demonstrate that maintenance of the habits and skills for performing in certain high speed exercise programs support necessary orthostatic tolerance and endurance of acceleration throughout a period of hypokinesia with head-down tilt.

Interesting scientific data on hemodynamic effects of hypokinesia and immersion were presented by T.A. Krupin and L. A. Fotin (Institute of Biomedical Problems). Changes in cerebral circulation and endocrine status in response to lower body negative pressure were discussed by R.A. Tigranyan et al. (Scientific Research Institute on Standardization and Monitoring of Drugs, USSR Ministry of Health.) V. Ye. Zaychik, et al. (Scientific Research Institute of Medical Radiology, USSR Academy of

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Medicine) delivered a methodological paper on potential for noninvasive determination of concentration of calcium and other elements in the human body using a set of radiometric devices and techniques of neutron-activation analysis.

The sessions devoted to effects of extreme physical and chemical environmental factors included papers on the physiology of extreme states in humans exposed to high and low temperatures, hygienic aspects of improving microclimates standards for industrial settings, principles for creating and tactics for applying individual protection systems (L.G. Arutyunyan et al., Scientific Research Institute of General Hygiene and Occupational Disease, USSR Academy of Medicine; G.V. Bavro et al., Institute of Biophysics; R.F. Afanas'yeva, Scientific Research Institute of Industrial Hygiene and Occupational Disease, and others). A great deal of attention was devoted to consideration of combined effects of poisons, and combined effects of chemical and physical factors, and also the role of the immune system in physiological adaptation to effects of chemical factors in an industrial setting (V.V. Kustov, et al., Institute of Biophysics; V.T Tulebekov, Institute of Physiology and Experimental Pathology of High Altitudes, Kirghiz Academy of Sciences, and others).

The section entitled "Correction and Restoration of Human Functional State Under Exposure to Extreme Factors" considered a broad range of issues relating to techniques and means for correcting human functional state under exposure to extreme factors, evaluation of their effectiveness, and mechanisms underlying the effects of various corrective measures.

Papers by P.P. Denisenko (Leningrad Medical Institute), and S.S. Loseva (Scientific Research Institute of Toxicology, USSR Ministry of Health) were devoted to general fundamental issues related to selection of drugs for pharmacological protection of individuals exposed to extreme factors. It was noted that, today, pharmacological means of protection must involve multiple drugs and affect neural and neuroendocrinological regulation and metabolic processes. These papers further emphasized that the problem of pharmacological protection from effects of extreme factors has two clearly differentiated aspects -- the prophylactic and the therapeutic, and this must be considered when new means of pharmacological protection are developed.

Great interest was shown in use of nonpharmacological methods for correcting, and increasing the work capacity of individuals exposed to adverse conditions. A paper by V.I. Il'in (Sechenov Medical Institute) presented a general taxonomy of nonpharmacological means for protecting individuals from extreme factors: means for phrophylaxis, autocorrection, and rehabilitation. It was noted that one of the most promising trends in the development of new measures for individual protection is the development of remote physical effects.

A number of reports discussed the issue of controlling human functional capacities using nonpharmacological various techniques and means, including acupuncture and related methods (A.M. Vasilenko, Central Scientific Research Institute of Acupuncture, USSR Ministry of Health; A.M. Karpukhina, I.A Chaychenko et al, Scientific Research Institute for Psychology, Ukrainian

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Ministry of Education), psychotherapy (I.N. Kalinauskas et al., Scientific Research Institute for Psychology), and physiotherapy (K.V. Sudakov et al., P.K. Anokhin Institute of Normal Physiology). V.S. Chugunov et al., considered the use of combinations of nonpharmacological measures for correcting human functional state. They emphasized the importance of research on the sympathetic-adrenal system in the development of a complex treatment program for individuals experiencing emotional stress.

Another area considered at the conference was the automation of biomedical research on human functional state under exposure to extreme condtions.

The recommendations made by the conference stressed the need to conduct further research on the physiology of extreme states and means of individual protection, particularly in the area of developing theoretically grounded parameters and criteria for assessing human physical and psychological work capacity under extreme conditions, ongoing diagnostics and physiological mechanisms underlying short- and long-term adaptation to exposure to extreme factors, prediction of functional states and individual protection against the effects of extreme factors, neurophysiological aspects of tolerance and adaptation of humans to adverse factors, and search for ways to maintain work capacity and increase physiological stability under exposure to such factors, evaluation and correction of the possible remote effects of extreme factors, and development of efficient approaches to creation of highly effective and physiologically acceptable means of individual protection.

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16. Abstract

This is the fifteenth issue of NASA's USSR Space Life Sciences Digest. It contains abstracts of 59 papers published in Russian language periodicals or presented at conferences and of two new Soviet monographs. Selected abstracts are illustrated with figures and tables from the original. An additional feature is the review of a conference devoted to the physiology of extreme states. The abstracts included in this issue have been identified as relevant to 29 areas of space biology and medicine. These areas are adaptation, biological rhythms, biospherics, body fluids, botany, cardiovascular and respiratory systems, endocrinology, enzymology, equipment and instrumentation, exobiology, genetics, habitability and environmental effects, human performance, immunology, life support systems, mathematical modeling, metabolism, microbiology, musculoskeletal system, neurophysiology, nutrition, operational medicine, perception, personnel selection, psychology, radiobiology, reproductive biology, and space biology and medicine.

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